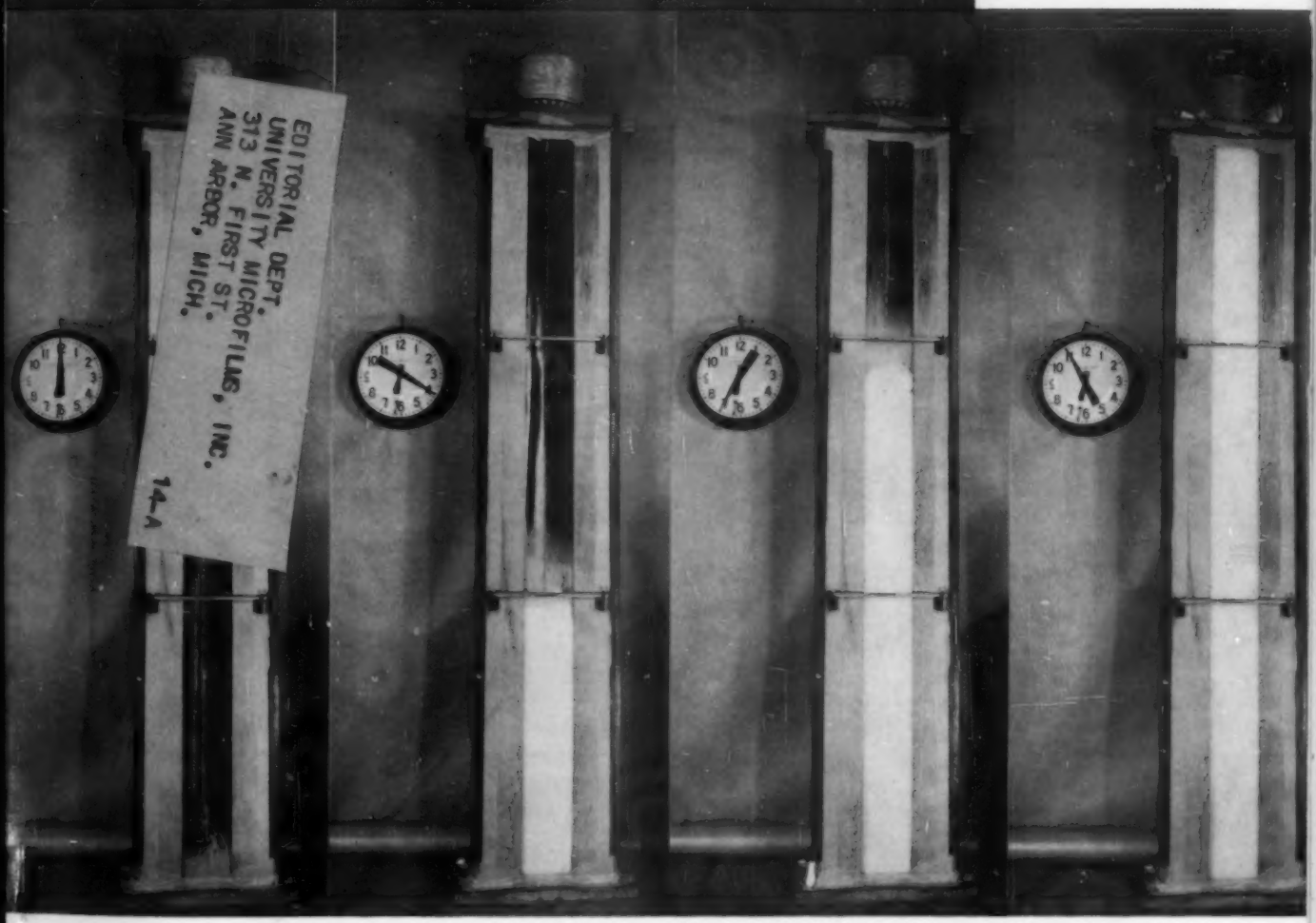
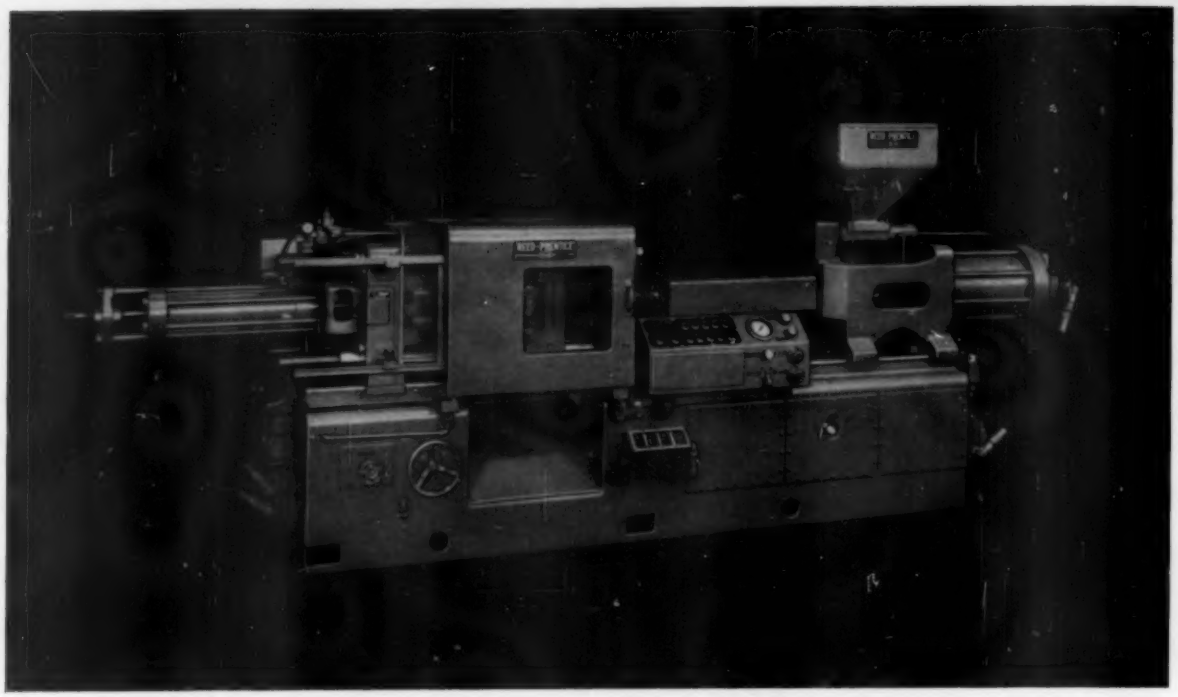
THE SOCIETY OF PLASTICS ENGINEERS JOURNAL



Liquid phenolic resin being foamed in place in 55 seconds. For technology and applications of foams, see pages 955, 957, and 961.

NOVEMBER 1959 • VOL. 15, NO. 11



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gives you longer stroke . . . larger platens

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Mold clamping stroke (adjustable)	6¼ to 11½"
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Space between tie bars	15½ x 15½"
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Cycles per hour (maximum)	470

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Photomicrograph of a Polypropylene crystal

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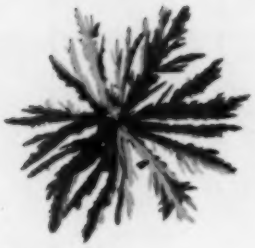

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Customer Service Department • AviSun Corporation • Marcus Hook, Penna.

pylene

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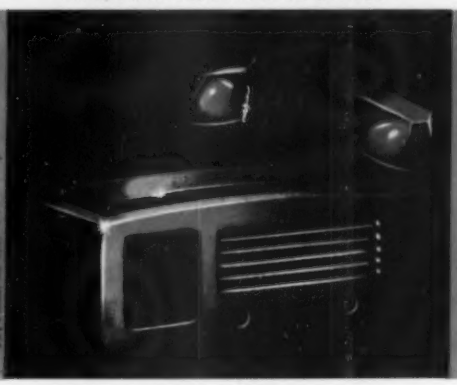

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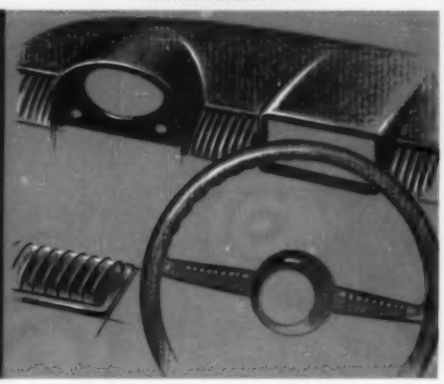

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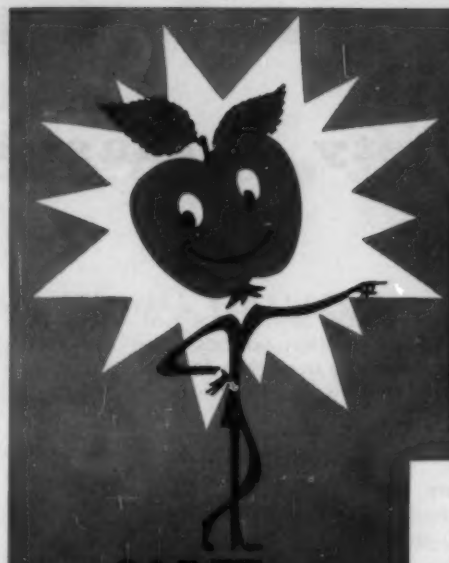

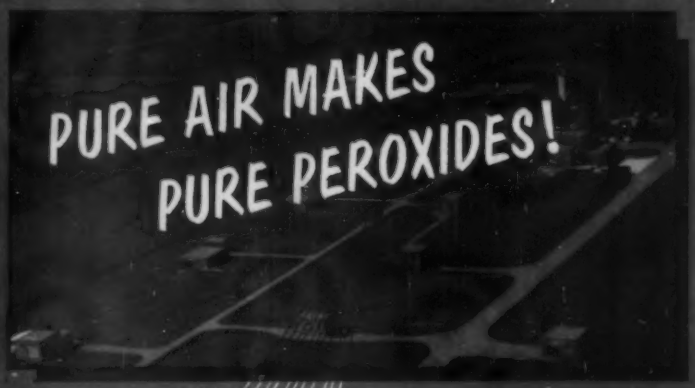

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The Society of Plastics

COVER

In 1947, consumption of plastic foams was just about nonexistent. In 1958, about 60 million pounds were consumed. **Cover** shows one of commercially available foams—phenolic—being "foamed in place." For articles, see below.

TECHNICAL ARTICLES

Plastic Foams—A Directory
C. R. Davall, Union Carbide Plastics Co.
A look at commercially available foams—how they're made, their properties, their uses 955

Effects of Tertiary Amine Catalysts on Some Foam Properties
G. T. Gmitter, E. E. Gruber, R. D. Joseph, General Tire & Rubber Co.
With proper choice and use of catalysts, significant improvements in cushioning properties of polyester urethane foam can be made 957

Designing Rigid Urethane Foams for Low Moisture Permeability
C. Minor Barringer, Du Pont Co.
Factors affecting the preparation of low temperature insulation foams 961

Low Pressure Injection Molding
Gordon Cooper, International Vulcanizing Corp.
Extrusion molding offers advantages in producing a very uniform melt 966

Plastics in the Auto Industry—A Symposium
A group of articles based on the Detroit RETEC, June 30, 1959
Plastics vs. die-casting, plastic tubing in automobiles, blow molding, and the growth of plastics in European cars 968

Thermoset Laminated Plastics in Electronic Applications
Paul V. Brown, Taylor Fibre Co.
A method for determining the coefficient of expansion of laminates 974

Plastics as Construction Materials in the Steel Industry
Joseph Bigos, U. S. Steel Corp.
New developments in combining plastics and steel 978

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SPE JOURNAL FEATURES

Speaking of Extrusion—Extruder Scale-Up Theory
B. H. Maddock, Union Carbide Plastics Co.
Applying theory to practical scale-up problems 983

Moldmaking—Special Considerations in Injection Mold Design
Ernest J. Csaszar, Newark Die Co.
Balancing, cooling, and automation—important factors in mold design 987

Molding Cycles—Improving Cycles through Machine Modification
Milton A. Sanders, Precision Molding Incorporated
Before you buy new machines—consider the possibility of modification of your old ones 989

Committee Report's—SPE's Committees and Their Objectives
A Staff Feature
Committee work is one way SPE's members can increase their own stature and also work for the good of the plastics engineering profession 992

National Action—SPE's New National Officers
A Staff Feature
George W. Martin named new SPE President 994

Annual Technical Conference
Chicago prepares for the 16th ANTEC 936

DEPARTMENTS

Editor's Notebook 923
Technical Meetings Calendar 995
Section News 996
About Members 1001
Plastics Around the World 1003
Book Reviews 1010
Employment and Service Guide 1012
Advertisers' Index 1012

NEXT MONTH

Extrusion—latest developments in extrusion of linear polyethylene.

For Economy-Minded Molders—Use of reground glass-filled polystyrene.

A New Method—Determining specific heats of polymers.

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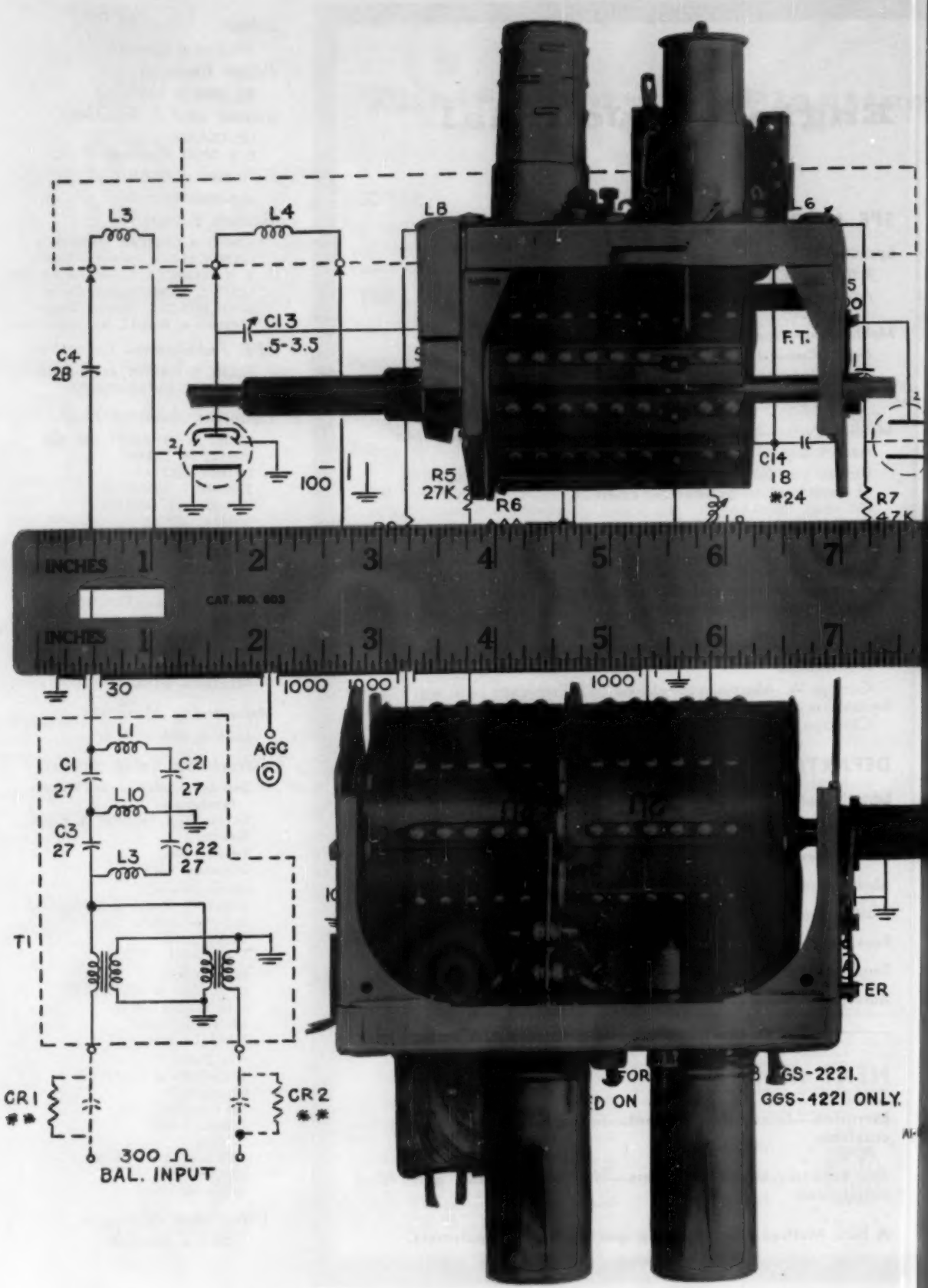
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Automatic tuning for television that eliminates troublesome manual fine tuning has been achieved by Standard Coil Products in its new GG-4200 Automatic Tuner and Station Selector.

PLASKON Alkyd figured prominently in this development due to these *unusual electrical qualities:*

- Dielectric stability of tuner segments molded from PLASKON Alkyd gives a new high in VHF performance by reducing oscillator frequency drift.
- Changes in dielectric constant due to time and elevated temperatures are minimized.
- Dimensional stability of Alkyd maintains circuit constants. This prevents change in relationship between coils, contacts and other circuit elements—thus stabilizing circuit capacitance.

PLASKON Alkyd aided the molder Wilcox Plastics, with these *outstanding molding properties:*

- Rapid molding cycles at low molding pressure permits mass production of intricate pieces.
- Uniformity of this Alkyd molding material provides unvarying precision of each molded part.
- The high mechanical strength of PLASKON Alkyd molded parts helps to accelerate separate staking operation for insertion of small contacts.

PLASKON Alkyd is outstanding for the qualities most necessary in molded parts for electronic and electrical applications. Competent Plaskon representatives will be glad to discuss material recommendations and fabricating techniques to fit your performance requirements.

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Play-proof Properties Spark New Product Idea

Developing a new product? Grex high density polyethylene could stir up as much excitement for you as it's doing for Revell, Inc. Their new product combines the toughness of Grex with the appeal of fantastic animal characters that roam the pages of Dr. Seuss' juvenile books. Sold in kits of interchangeable parts, Dr. Seuss Zoo inhabitants snap together and pull apart in millions of ways—are colorful and strong enough to take the roughest treatment without breaking, chipping or cracking.

There is virtually no limit to profitable new product applications with this versatile Grace plastic. Here are just a few of its advantages: It can be fabricated at low cost and molded in any color. It is a hard, stiff, rugged thermoplastic that takes boiling or freezing without losing its shape or strength.

Find out more about high density polyethylene for the new product you have in mind by calling in the experts. Grace has the production facilities, technical service and experience to help put your product in the Grex profit parade. We're easy to do business with.

Grex is the trademark for W. R. Grace & Co.'s Polyolefins.

W.R. GRACE & CO.
POLYMER CHEMICALS DIVISION
CLIFTON, NEW JERSEY

THE EDITOR'S *Notebook*

Writing for Publication

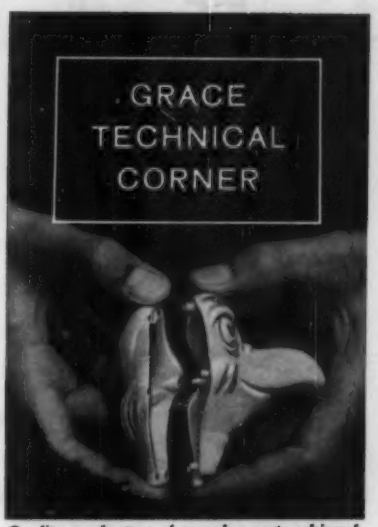
With the 16th ANTEC around the corner, considerable attention is focused on preparation of papers. And while most 16th ANTEC manuscripts have already been written, the subject is "hot" and uppermost in the minds of many chemists and engineers. The following guidelines may help in their preparation of papers, not only for presentation at future SPE meetings, but also for meetings sponsored by any technical society.

The manuscript. All manuscripts submitted for publication should be typed doublespaced. Why? Because the editors' corrections and proof-readers' marks can be made more easily and neatly, and the printer can follow a doublespaced manuscript more easily. Number of copies submitted is important, too. Since most technical publications have technical manuscripts reviewed by at least one and more often two experts in the field, three copies should be sent to the editor.

Tables. In technical writing, it is important to get thoughts down on paper. But it is more important to get those thoughts from the printed page and into the readers' minds. Tables are one of the most effective devices for accomplishing this, **when they are properly prepared.** One thought to remember: Don't make the reader work hard to get the meaning of the table. Give a short title to the table, and then write an additional brief statement, subtitle if you will, which gives the reader the significance of the table at a glance. For instance, take a table with the title "Effect of Cooling of Mold in Production." By itself it means nothing. The reader has to dig out the significance from the table. If he's in a hurry, he may not take the time to do so. Think how much more helpful this table becomes if a short sentence appears under the main title—"Mold cooling resulted in a serious reduction in output." The reader's mind becomes oriented at once.

Figures. Original artwork is a must for high-caliber reproductions. On captions, the rules for preparing table captions also apply to figures. Consider a plot of foam time versus percent HCl added. The caption "Foam Time vs. Percent HCl" is fine to identify the graph. But a short sentence to the effect "Hydrogen chloride in small amounts decreased reaction mixture activity" would give the reader the significance of the figure at a moment's glance. Also—don't staple together photographs or other figures.

A limited number of tear-sheets of this article are available. Please address requests to SPE Journal, 65 Prospect St., Stamford, Conn.



Quality production of complex parts achieved with fast cycles by specifying Grex.

Here you see 2 of 19 parts that make up Gowdy the Dowdy Grackle. Note their detail, irregularity of contour and how they snap together. In addition to Gowdy, Revell markets three other Dr. Seuss characters that are equally complex. The use of Grex high density polyethylene and substantial technical assistance from Grace helped Revell solve design and molding problems for this project. You can expect the same kind of benefits by working with Grace.

Design requirements of these Revell toys called for rigid parts with high impact strength. Resiliency was also needed to make snap plugs or poppets practical devices for snapping the parts together firmly and pulling them apart easily. Grex combines all three properties required—rigidity, high impact strength and resiliency. And the fact that the most intricate details can be molded with Grace's plastic provided freedom in reproducing these fantastic characters in three-dimensional shapes as suggested in Dr. Seuss books.

Mold layout and production. Revell's two molds for Dr. Seuss toys are among the most complicated ever used with Grex. They contain over 60 cavities; each cavity has an irregular parting line and many have serious undercuts. Stripping the parts from molds like these would have been either too slow for economical production or completely impossible with other plastics. High density polyethylene, however, solidifies in the mold at a high temperature yet remains flexible for stripping at fast cycles. Production efficiency was increased by using beryllium copper in many cavities and cores for effective heat removal.

Interested? If you have a job for high density polyethylene count on Grace for help. Now's the time to contact:

Technical Service Department,
W. R. Grace & Co., Clifton, N. J.

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The same with alkyd resins—another end use where Celanese trimethylolpropane's high production and low price have enabled paint and coatings manufacturers to plan ahead with more confidence.

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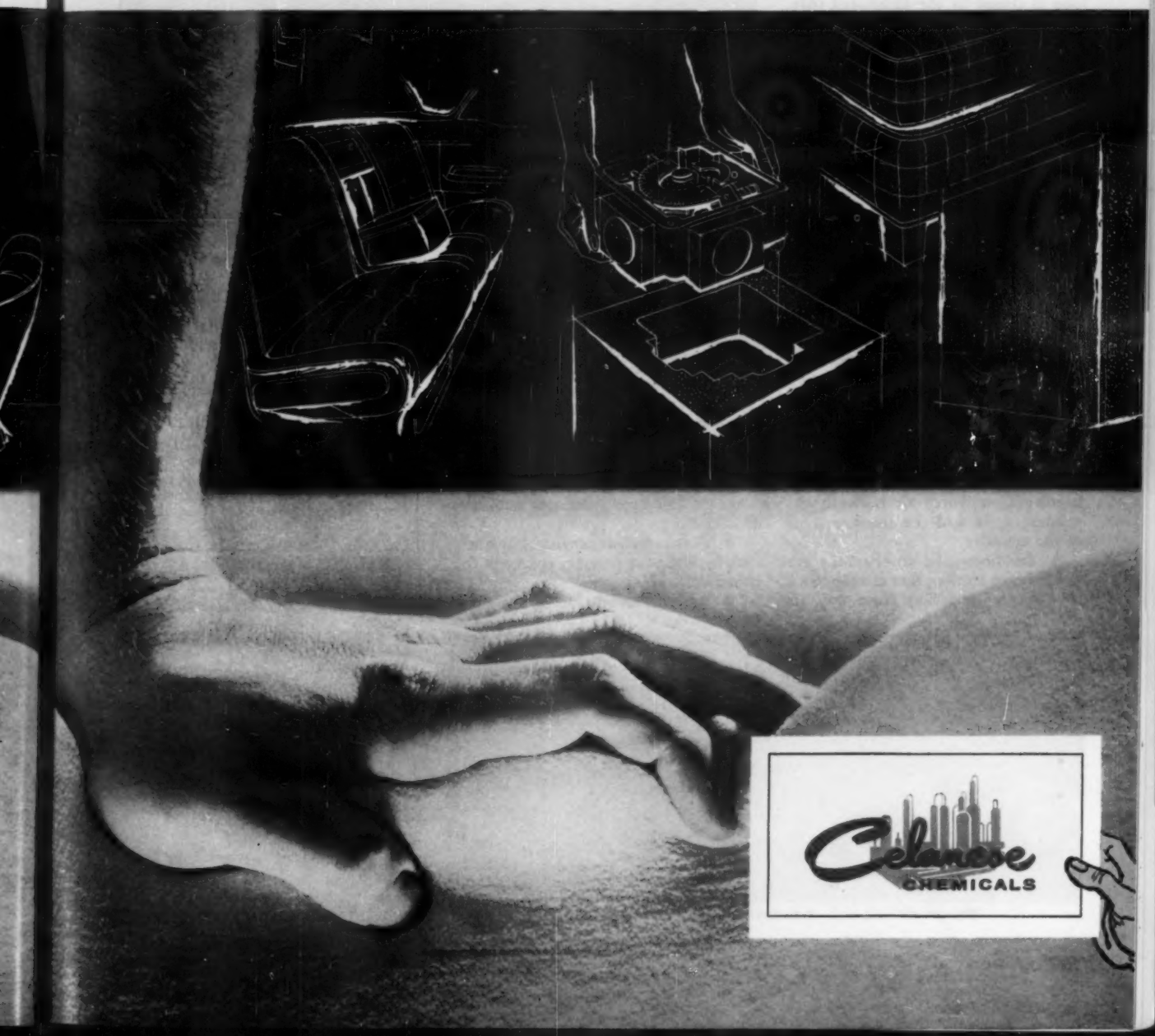

The principle and advantages of induction heating as applied to Farrel Inductomatic extruders

Successful processing of plastic materials in an extruder depends largely upon the control of the material temperature within the various zones of the extrusion chamber.

With Farrel Inductomatics, heating is by the induction method, with separate primary coils for each of the required heating zones. The coils are wound around the extruder body with sufficient radial clearance to provide space for a cooling medium.

When 60-cycle alternating current is passed through these coils, it produces a magnetic flux with a path as shown in the diagram. The magnetic loop is closed by the laminated core segments, which are made from material with high permeability, thus providing minimum resistance to the magnetic flux.

The magnetic flux, which alternates with the same frequency as the primary current, induces a secondary voltage in the cylinder wall. The secondary voltage produces a secondary current, which, in turn, generates the heat that raises the temperature of the plastic material as it is forced through the cylinder. This is similar to a short-circuited transformer with a single secondary coil. The extruder body functions as secondary coil and, at the same time, as part of the magnetic core.

HEAT CONTROL

In order to control the temperature of the wall satisfactorily, the heating system is augmented by a cooling system. Separate blowers, for each heating zone, force air between the primary coils and the outer surface of the cylinder.

A thermocouple, inserted in the wall in each section, acts as a feedback to indicate deviation from any set temperature level. Because of the quick response of induction heating, a simple on-off control is all that is necessary. The control automatically turns the heat off if the temperature rises above a previously determined level, and turns it on when the temperature drops below this level. The cooling system is controlled in the same manner.

ADVANTAGES

In comparison with extruders in which the heat is applied to the outside surface of the cylinder, Farrel Inductomatics offer a number of important advantages.

1. *Better temperature control.* Because the heat is generated closer to the plastic stream, there is less overshoot when approaching a temperature setting.
2. *More efficient cooling.* Air ducts are between the primary coils and the chamber wall.
3. *Faster heat-ups* are permissible because high thermal stresses are not introduced.
4. *Higher production rates* result from faster heat-ups, faster changeovers and less scrap.
5. *Lower maintenance.* Induction coils have unlimited life.
6. *Reduced labor cost.* Minimum operating attention is required.

FOR FURTHER INFORMATION

Send for a *free* copy of *new* bulletin 208, which describes Farrel Inductomatics in detail.

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Diagram showing path of magnetic flux and secondary current.

FB-1182

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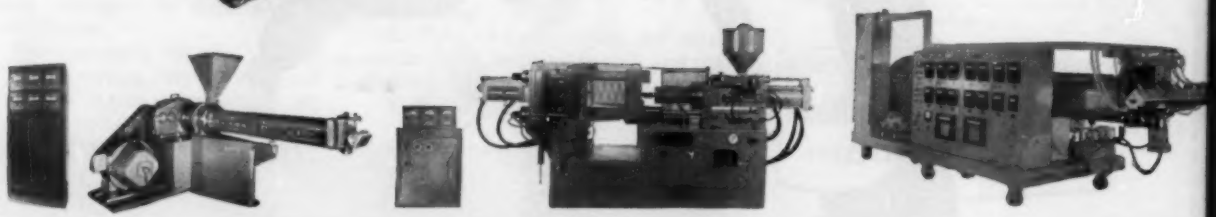

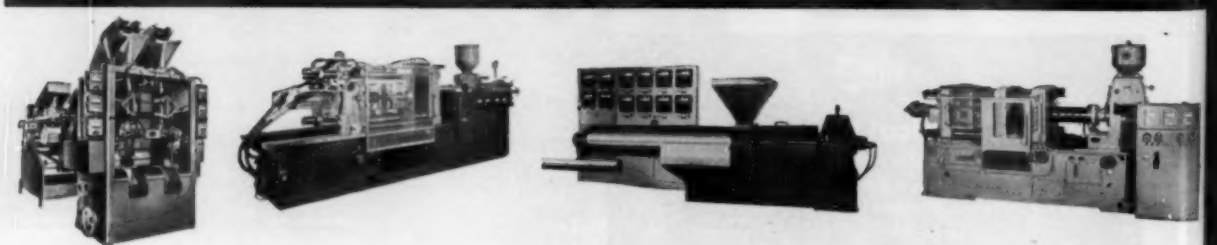

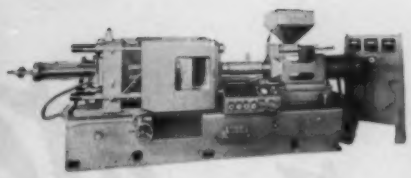
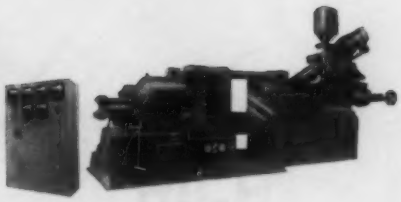
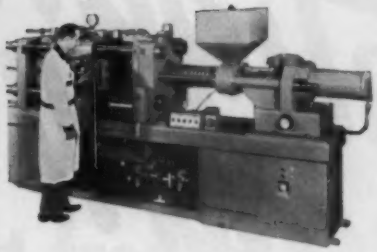
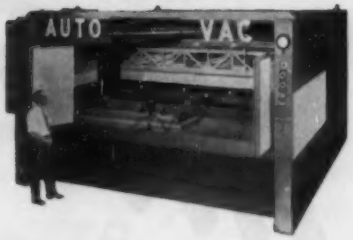

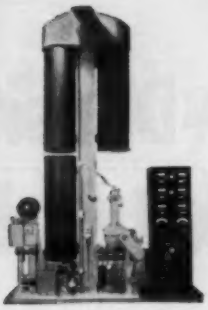

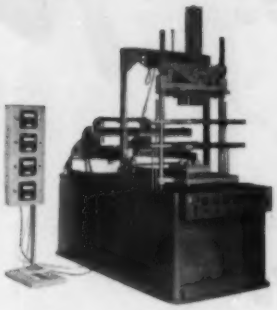
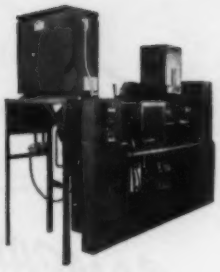
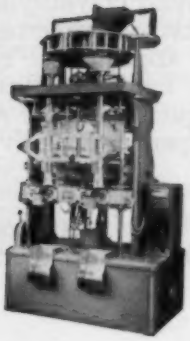
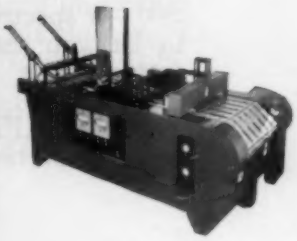

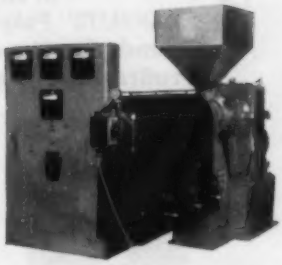
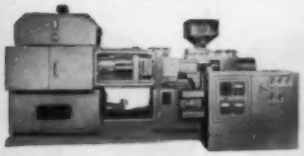

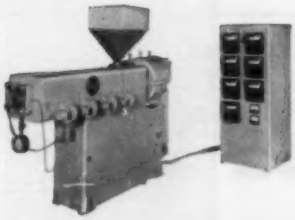

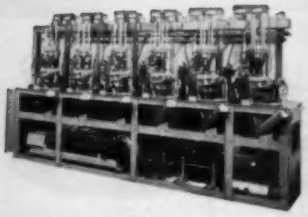

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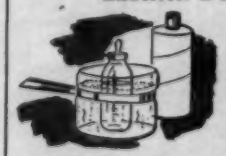

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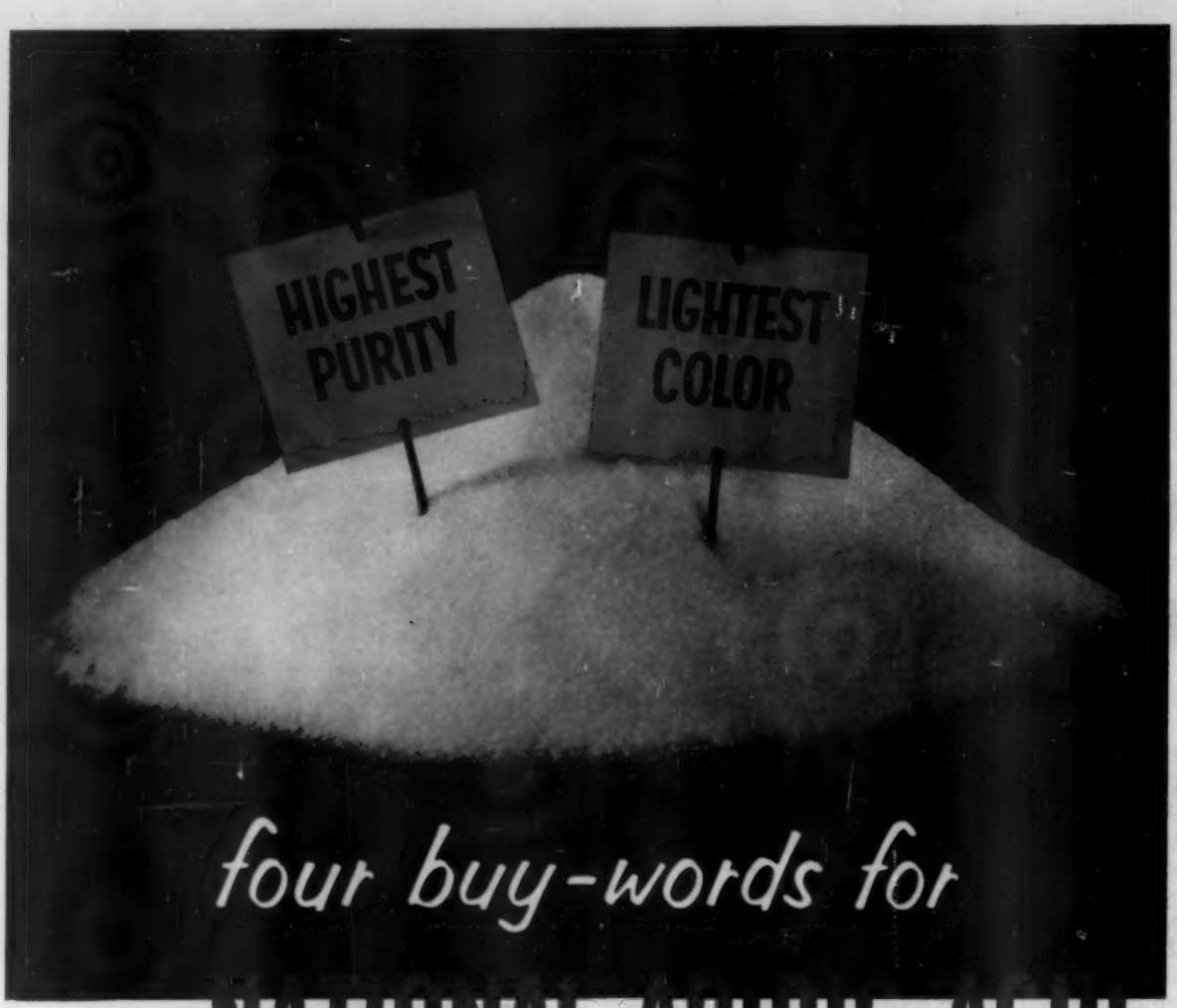

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For casting compounds, laminated structural parts, potting and encapsulating EPI-CURE 855 provides several unique advantages.

Lower viscosity improves mixing and handling ease, eliminates the use of diluents in many cases and often lowers the cost of finished compounds.

Complete compatibility with EPI-REZ® 510 and similar resins allows faster and more uniform mixing. Bubbles come out faster and preheating and waiting periods before application are eliminated. Now you can handle compounds at lower temperatures with less sweat-out.

Longer pot-life permits larger batches and more time for application. After application there is more time for bubbles to surface and break resulting in better wetting.

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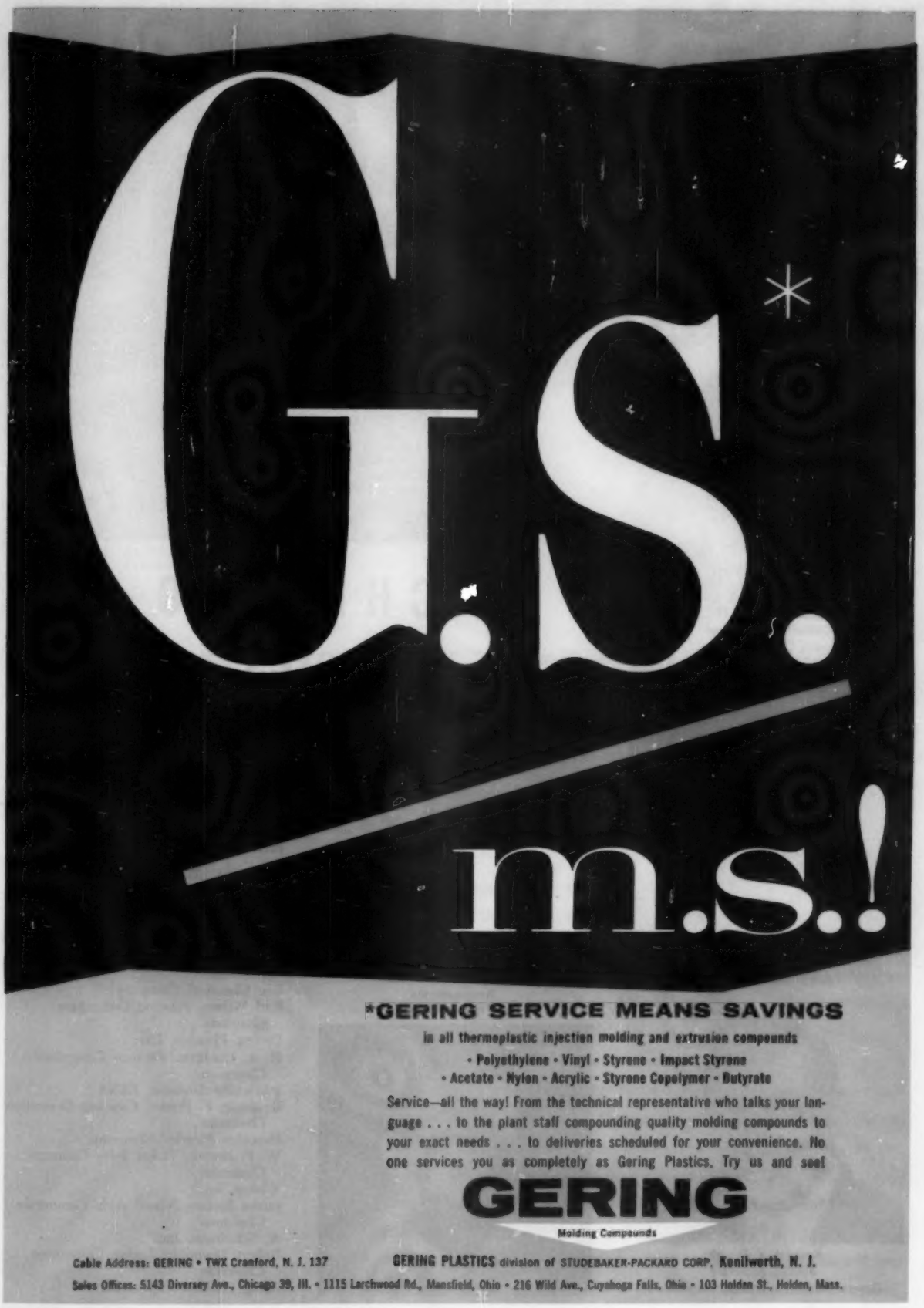

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a message to spe members: from

Franklin L Fine

General Chairman, 16th ANTEC

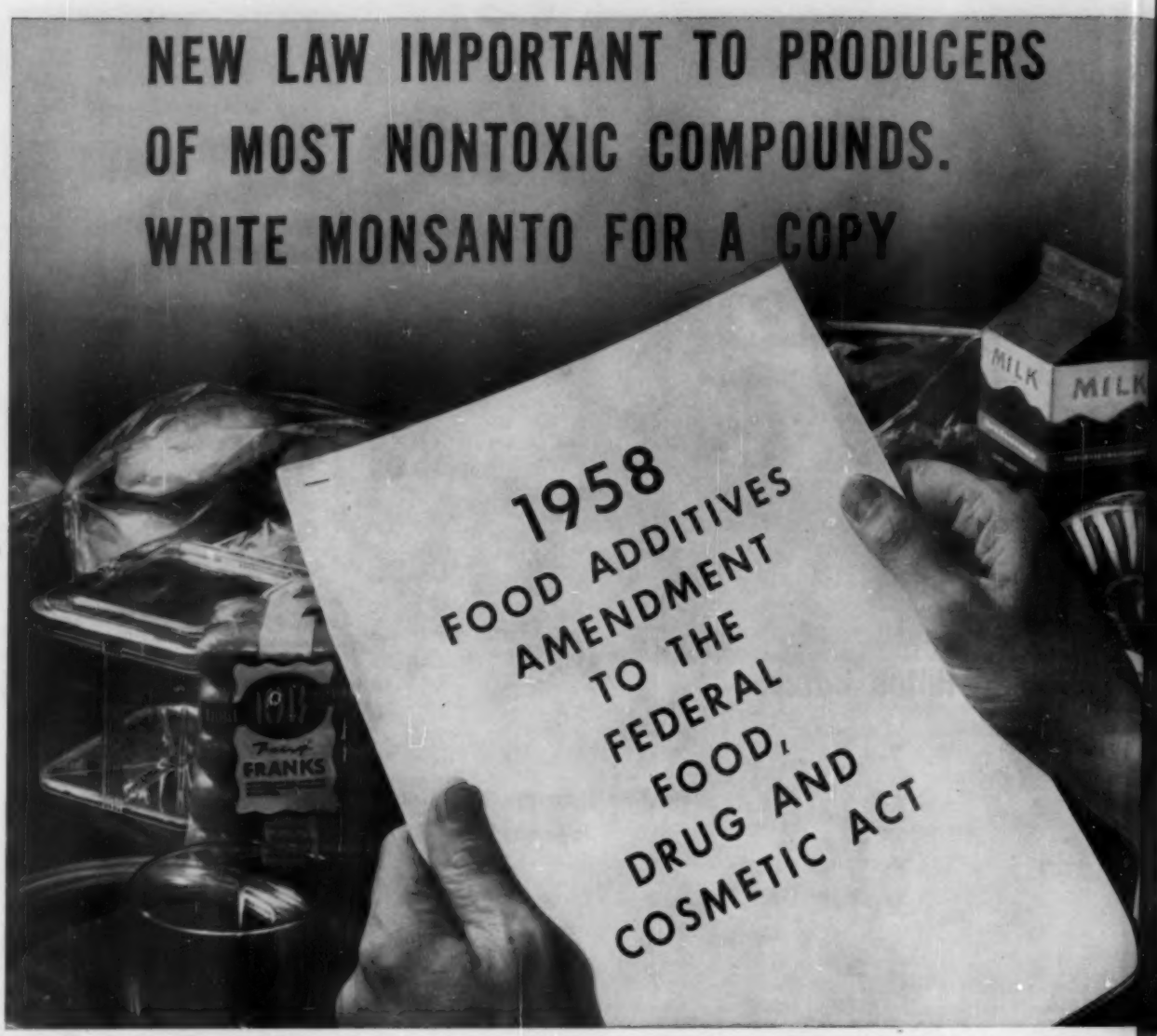
January 12-15, 1960
Conrad Hilton Hotel

Your Committee for the 16th Annual Technical Engineering Conference to be held in January is finalizing an excellent technical program in keeping with the conference theme:

Professional Achievements
and
Approaching Opportunities
in the
Growth of Plastics Engineering.

Complete sessions of several papers each are being devoted to polymer structure, injection molding, vinyl plastics, extrusion, reinforced plastics, packaging, new materials and other equally important topics. A number of the Professional Activities Groups also have plans to hold special afternoon programs following the technical sessions to discuss matters of specific interest. For details on the technical sessions and PAG Group Meetings, you are referred to the full conference program which will be in your hands shortly. Companies wishing to register for this meeting are urged to promptly send their applications to the National Office.

On the lighter side and as a special inducement to the ladies, the SPI-SPE Annual Christmas Party and Dance normally held in Chicago is being combined with the SPE ANTEC Banquet on Thursday evening, January 14th. Your Committee has been working diligently to make this one of the best technical conferences our Society has presented. We believe you will feel well rewarded by being present and urge you to make plans now to attend.



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SEVEN APPROVED PLASTICIZERS FOR

Monsanto's seven approved plasticizers help you meet strict nontoxic requirements for your plastic compounds and give you "formulating flexibility" as well. You can choose from four ester-types (phosphate, glycolate, adipate, and phthalate) to best meet your needs for physical properties, processing ease and speed, or cost reductions.

Five Monsanto plasticizers—Santicizer 141, Santicizer E-15, Santicizer B-16, Monsanto di-isobutyl adipate and diethyl phthalate—have earned *complete acceptance* from the Food and Drug Administration for use in plastic packaging for aqueous, fatty or nonfatty foods. By specifying these plasticizers, you can be more certain your compounds are safe and meet fully the requirements of the 1958 Food Additives Amendment to the Federal Food, Drug and Cosmetic Act.

For a quick start to solving your problem in a plastic application having nontoxic considerations, check the tables shown here. They're a convenient guide to industry's largest and most diversified line of plasticizers for nontoxic formulations . . . from Monsanto. Write for more details, samples, and compounding help today.

PLASTICIZER COMPATIBILITY WITH SIX PLASTIC MATERIALS

Monsanto Plasticizers	Polyvinyl Chloride	Polyvinyl Acetate	Cellulose Acetate	Ethyl Cellulose	Acrylic Type	Nitrile Rubber
Santicizer 141	C	C	SC	C	C	C
Santicizer E-15	C	C	C	C	C	—
Santicizer B-16	C	C	LC	C	C	C
Di-isobutyl Adipate (DIBA)	C	C	I	C	C	C
Diethyl Phthalate	LC	C	C	C	C	C
Dioctyl Phthalate (DOP)	C	SC	I	C	SC	C
Di-isoctyl Phthalate (DIOP)	C	SC	I	C	SC	C

C (Compatibility)—25-100 pts. per 100 parts resin. LC (Limited Compatibility)—10-50 pts. per 100 parts resin SC (Slight Compatibility)—1-25 pts. per 100 parts resin. I (Incompatible)

JOB-RATED PLASTICIZER PERFORMANCE (WHERE "1" IS BEST, BASED ON TYPICAL RESULTS)

Monsanto Plasticizer	Non-Toxicity	Low Volatility	Grease & Solvent Resistance	Water Resistance	Low Temperature Flexibility	Low Cost
Santicizer 141	1	1	1	2	2	1
Santicizer E-15	1	4	1	3	3	2
Santicizer B-16	1	2	2	3	3	2
Di-isobutyl Adipate (DIBA)	1	3	2	3	1	2
Diethyl Phthalate	1	5	1	2	3	1
Dioctyl Phthalate (DOP)	X	1	3	1	2	1
Di-isoctyl Phthalate (DIOP)	X	1	3	1	2	1

X—Accepted for use with foods of high water content only.

NONTOXIC PLASTIC APPLICATIONS

NEW BOOKLET NOW AVAILABLE

Gives specific advantages in numerous applications, describes outstanding features and lists specification properties of seven Monsanto nontoxic plasticizers. For your copy, use the convenient coupon.

With no bias in favor of a single nontoxic plasticizer, Monsanto develops plasticizing systems custom-made to fit your needs best. **Santicizer: Monsanto T. M., Reg. U. S. Pat. Off.**

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Please send the new booklet, "Seven Monsanto Plasticizers for Nontoxic Applications" plus a copy of the 1958 Food Additives Amendment to the Federal Food, Drug and Cosmetic Act.

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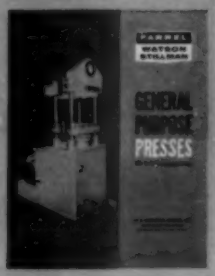
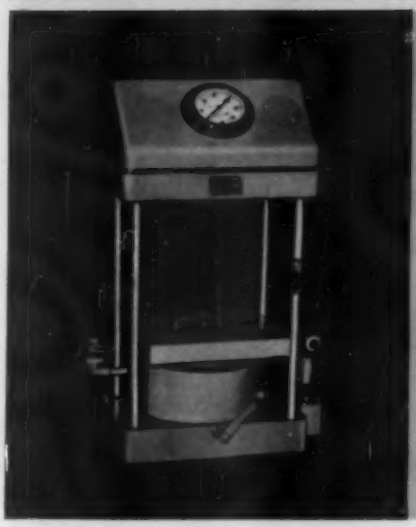
GENERAL-PURPOSE PRESSES

Electrically operated, automatic, single-cycle control, in conjunction with a timer, governs the press dwell under pressure. This relieves the operator of the timing task and eliminates the possibility of error, assuring uniformity of operation, and a higher production rate. Available in 30- to 200-ton capacities, these presses can be used for rubber and plastic molding, and for metal forming, straightening or bending, hobbing and forcing. Ask for comprehensive bulletin 370-E.





LABORATORY PRESSES

Farrel Watson-Stillman laboratory presses are designed for experimental work wherever pressures of 30 to 100 tons are required in comparatively small areas. For increased versatility the press can be equipped with electric- or steam-heating plates or combination electric-heating and water-cooling plates. Equipped with non-indicating type thermostatic controls conveniently mounted on the gauge panel. Bulletin 350-C gives complete specifications and details.

PRESSES *for short runs, laminating or laboratory work*

The result of 110 years of concentration on the development of hydraulic equipment, Farrel Watson-Stillman presses spell the maximum in versatility. They are ideal for short run jobs, laboratory and experimental work or for laminating. Designed with a thorough understanding of industry requirements, either type may be transformed into a press capable of more highly specialized work, through the addition of a variety of optional features. A Watson-Stillman engineer will gladly discuss presses with you at your convenience.

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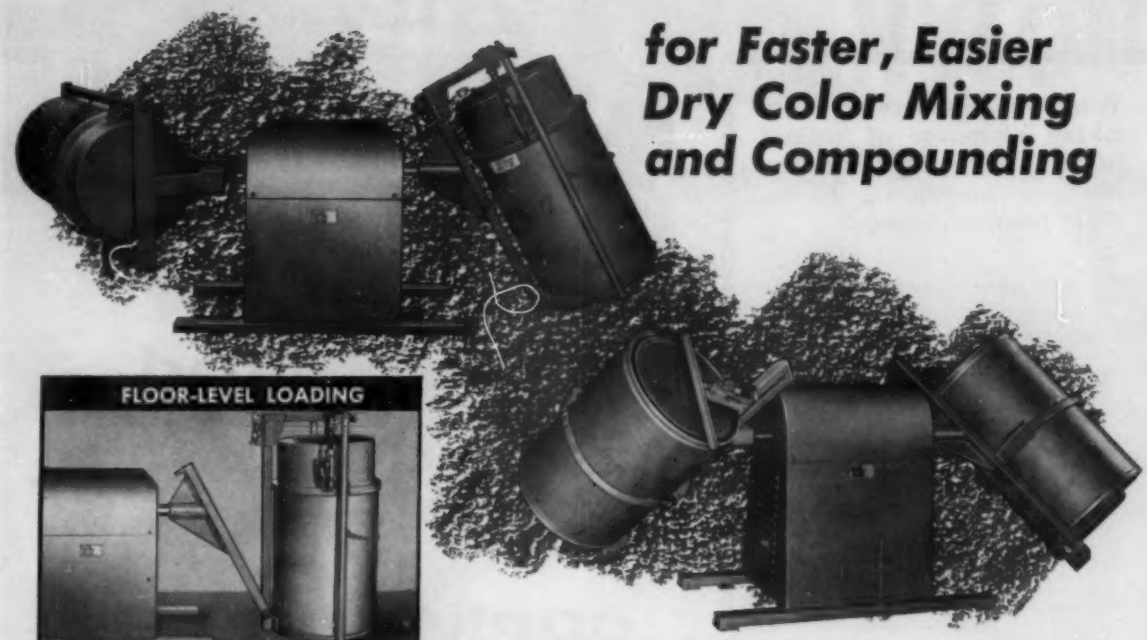
WS-69

"U.S." *HEAVY-DUTY* DRUM TUMBLERS

for Faster, Easier Dry Color Mixing and Compounding



17-G

You can save time . . . cut costs . . . speed production by tumble mixing colorants and molding materials right in their shipping drums. "U. S." Drum Tumblers are designed to do the job quicker, easier, more effectively.

These precision-built machines have sturdy welded construction for long life and trouble-free service. Their rugged steel bases provide rigid support for handling unbalanced loads. Positive roller chain drives, extra powerful motors and heavy-duty ball bearings assure smooth tumbling action under heavy loads.

Only "U. S." Drum Tumblers offer such extra ease of operation. Custom-built to meet specific mixing requirements, they are available with typical features shown at left — "floor-level" loading for quicker, easier drum handling; built-in drum extenders, providing extra space for thorough mixing of full drum loads; quick-acting toggle clamps for rapid opening or closing in one easy motion; adjustable drum holders to handle various size drums.

"U. S." Drum Tumblers are built in a range of sizes to handle standard fiber or metal drums; with motors of ¾, 1, 2, 3, and 5 h.p.; capacities from 250 to 500 lbs. per drum. Our Engineering Service Department will gladly recommend the proper unit to meet your specific mixing requirements. Write today for complete details.

PROCESS EQUIPMENT DIVISION

U. S. STONEWARE
AKRON 9, OHIO

OUR 100th YEAR

Many compounders are now taking advantage of rugged ROYLE SPIROD Extruders in their operations. Check these features:

1

New dual head arrangement for reclaiming or coloring procedure; allows continuous operation while fixtures and screens are cleaned.

2

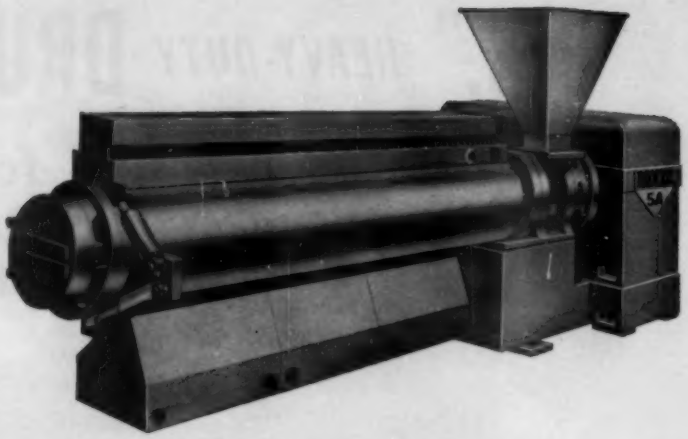
Thrust bearings with positive internal lubrication, designed for 10 years' minimum life.

3

New positive seal at stockscrew shoulder to prevent compound leakage with powder feeds.

4

Evaporative cooling system particularly effective for melt-fed polyethylene processing extruder.



Royle Spirod Extruders allow continuous, economical operation

JOHN ROYLE & SONS

Pioneered the Continuous Extrusion Process in 1880

London, England, James Day (Machinery) Ltd., Hyde Park 2430-0456. **Home Office,** V. M. Hovey, J. W. VanRiper, SHerwood 2-8262. **Akron, Ohio,** J. C. Clinefelter Co., BLackstone 3-9222. **Downey, Cal.,** H. M. Royal, Inc., TOpaz 1-0371. **Tokyo, Japan,** Okura Trading Company, Ltd., (56) 2130-2149.

ROYLE
Paterson, N. J.

John Royle & Sons, 8 Essex Street, Paterson 3, New Jersey

Please, send me full information about Royle Spirod Extruders.

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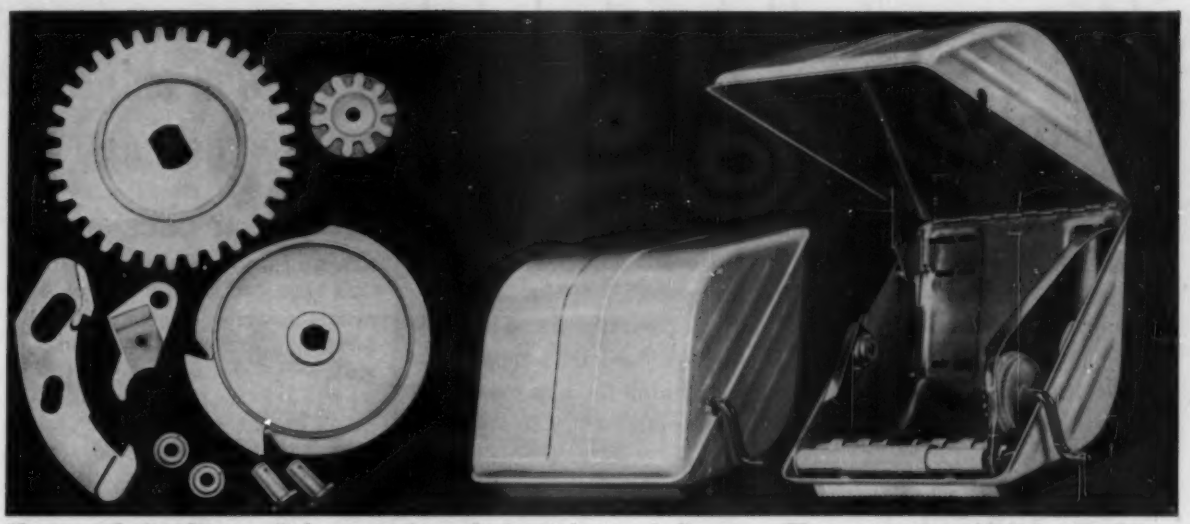
Company_____

Street_____

City_____ Zone_____ State_____

As they have been since 1880, Royle is first in Extruder development.

New ideas in **NYLON**



The use of nine Spencer Nylon parts instead of metal cut a pound from the weight of this Towlsaver paper towel dispenser. The parts are molded for Towlsaver by American Molding Co., San Leandro.

Spencer Nylon Gears Outwear Metal, Cut Product Weight, End Gear Noise

How Towlsaver, Inc., of Los Angeles produces a lighter, more quiet, trouble-free dispenser with parts molded from Spencer Nylon:

The moving parts in a paper towel dispenser must be able to take a lot of punishment. That's why Towlsaver, Inc., of 2639 South Garfield, Los Angeles, recently set out to find a better material to replace the metal gears in the Towlsaver dispenser. The metal gears, although case hardened, would eventually wear, and also were rather noisy.

The solution to this problem was found in tough, lightweight Spencer Nylon. The Towlsaver dispenser now contains nine parts molded from Spencer Nylon by the American Molding Co., 2002 Davis St., San Leandro, Calif.

"We are very pleased with the improvement in our dispenser since changing to nylon," reports Jack L. Perrin, president of Towlsaver, Inc. "By using nylon for these parts we have a virtually silent cabinet, and we have not experienced any gear failure because of wear. Also, the substitution of nylon has reduced the overall weight of our dispenser approximately one pound, which is an important freight saving."

There are important processing advantages, too, in Spencer Nylon. For one thing, Spencer Nylon contains far less water than other type nylons . . . saves you money because you don't have to dry it. Also, no other type nylon has the "body" needed for complicated shape extrusions.

It's easy to see why so many companies are switching to Spencer Nylon. For more information, contact Spencer's West Coast Sales Office, 1435 South LaCienega, Los Angeles.

SPENCER CHEMICAL COMPANY

SPENCER NYLON

General Offices. DWIGHT BUILDING, KANSAS CITY 5, MISSOURI

In its NOVEMBER ISSUE
MODERN PLASTICS
brings you these helpful articles

AND NOW...BLOW MOLDING. This latest plastics processing technique is on its way to becoming "big business", with 1,000 molders expected to be in the field by 1965 (there were 7 in 1957). Not only will it change the packaging market line-up, but it will also become an important factor in the toy, housewares and industrial component fields. Here is the first article outlining the market areas, application potentials, methods and materials available and machinery designed for this process.

FIRST COMMERCIAL DELRIN APPLICATIONS. Although Delrin acetal resin, the latest thermoplastic material to come to the market, is not yet in full commercial production, several significant applications have already been developed. Six of these are described in some detail in the article. In all cases they replace metal, providing better properties at lower cost.

DRY COLORING POLYPROPYLENE. Molders have found that many familiar dispersion aids are not entirely suitable for polypropylene. A new device has now been developed which is claimed to disperse dry colors satisfactorily in polypropylene. Article includes full-color illustrations which show the degree of dispersion obtainable, as compared with older methods.

EASY WAY TO CALCULATE INJECTION MOLDING SET-UP TIME. Nomograph and simple mathematical expressions permit ready determination of the time that must be allowed for set-up, a valuable contribution to planning molding jobs and checking the efficiency of an operation.

HOW TO SAW PLASTICS. Tips on the selection, mounting operation and maintenance of circular saws.

Plus many interesting "applications" stories not listed here.

A BRESKIN PUBLICATION

MODERN PLASTICS

Authority of the Field for 34 Years

COMING IN DECEMBER:

NEW BUILDING CONCEPT: THE MOSCOW PAVILION. A fully illustrated article describes in detail the interlocking, flower-like structures, molded of reinforced plastics, which are the basic units that made up the Moscow Pavilion. This unique architectural concept is not only an efficient shelter, but also doubles as a water-collecting device. The thinking behind it, its development and its fabrication are all discussed.

CHEMICAL STRUCTURES AND STABILITY RELATIONSHIPS IN POLYMERS. A discussion of the effect of thermal, ultra-violet and nuclear radiation energy, oxygen, water and various climatic environments on polymer structure, and thus on the aging of plastics.

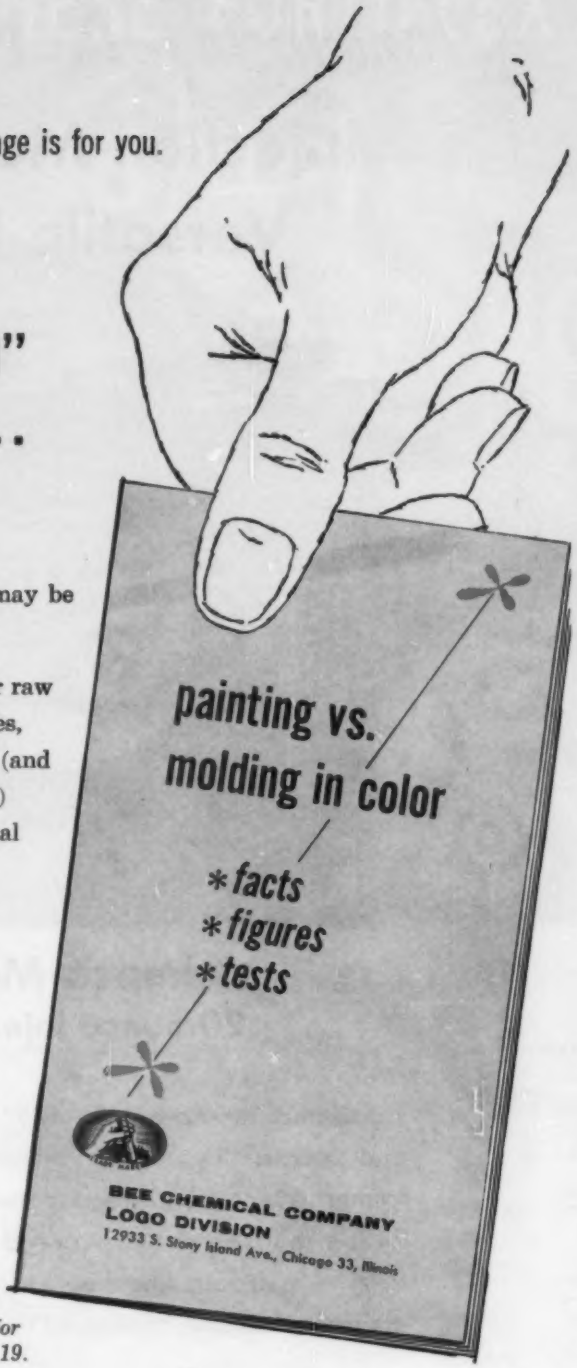
CHILL ROLL CASTING. With the introduction of high-density materials, this technique has grown in importance recently. Here are the methods that produce optimum results.

New Encyclopedia Issue

Just published, the 1,242-page MODERN PLASTICS ENCYCLOPEDIA ISSUE for 1960 furnishes subscribers with a wealth of valuable working information... through its articles, Buyer's Directory, charts, diagrams and tables. The Encyclopedia is the most inclusive, most authoritative reference work on plastics available.

If you buy special-color plastic parts, this message is for you.

This new production "tool" can cut your part costs . . .



If you buy special-color plastic parts, you may be paying more for them than necessary . . .

If your requirements for each special-color raw stock are below maximum-discount quantities, your parts will probably cost less painted (and molded from neutral or reprocessed material) than molded in color. And Bee Coatings equal or better finished part appearance and performance. Color selection—including metallics—is unlimited, offers numerous advantages in addition to low cost.

Painting is a useful production "tool"—not a cure-all. There are cases where painting pays, and others where molding in color is still best. Where pennies count it's wise to figure *every* part both ways—painted *and* molded in color.

Detailed information, including actual costs and other advantages, is yours for the asking. Write now for Bulletin A119.

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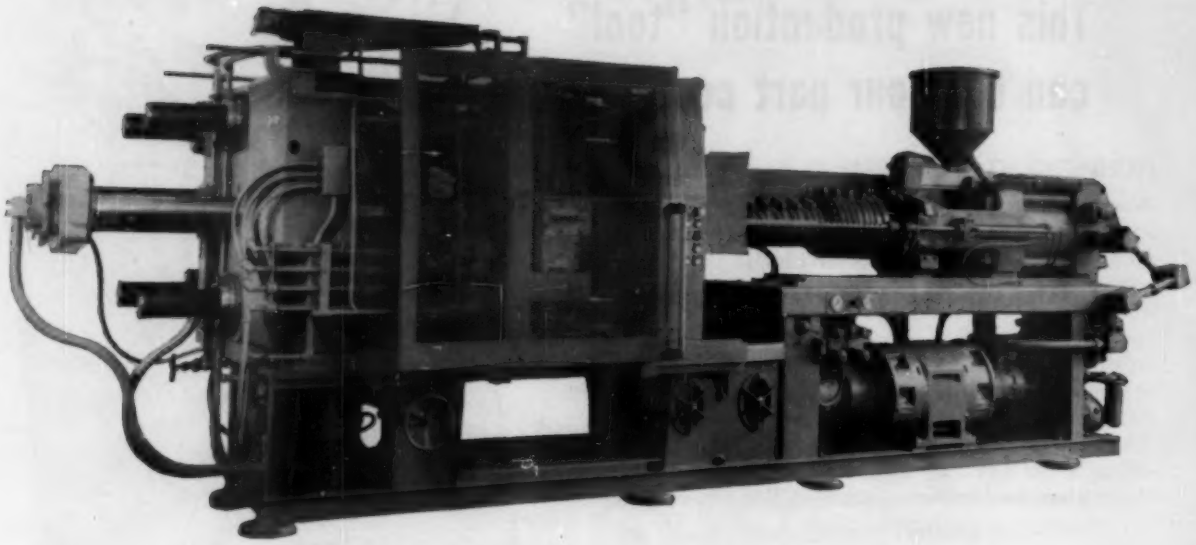
Injection Molding's Most Versatile Performer!



Impco Model HA16–425

20 ounce injection molding machine

The size of the new HA16-425 "Impco", combined with its speed and adaptability, make it Injection Molding's most versatile performer! Seven hundred and twenty dry cycles per hour at full 24½ inch stroke — two hundred pounds per hour plasticizing capacity — hydraulic knockout — live adjustments, are but a few of the many features contained in this machine. Let us show it to you.

IMPCO®

IMPROVED MACHINERY INC.

NASHUA, NEW HAMPSHIRE

In Canada, Sherbrooke Machineries Limited, Sherbrooke, Quebec

Export Distributors: Omni Products Corp., 460 Fourth Avenue, New York, New York

DESIGNED IN CELANESE FORTIFLEX...

RCA WHIRLPOOL
Air Conditioner Condensate Drip Pan
Injection-molded of Celanese Fortiflex A
by Metal Specialties Co., Cincinnati, Ohio
for Whirlpool Corp., St. Joseph, Michigan

Large-area injection moldings cut weight...can't rust

Good part performance dictated the selection of Celanese Fortiflex plastic for this air conditioner drip pan. Fortiflex supplied the toughness for thin-walled, lightweight construction plus corrosion resistance. Fortiflex is unaffected by hot or cold temperatures likely to be encountered in air conditioning systems.

Fortiflex is a designer's material. Five times stiffer than conventional polyethylene, and with superior surface hardness, Fortiflex can help you meet difficult specifications and cost limitations. For more information on this versatile plastic, return coupon below.

Celanese® Fortiflex®

Fortiflex...a Celanese plastic

Canadian Affiliate: Canadian Chemical Company Limited, Montreal, Toronto, Vancouver.
Export Sales: Amcel Co., Inc., and Pan Amcel Co., Inc., 180 Madison Avenue, N. Y. 16.

TYPICAL PHYSICAL AND CHEMICAL PROPERTIES OF FORTIFLEX

Properties of Fortiflex "A" Related to Melt Index

PHYSICAL PROPERTIES	ASTM METHOD	UNITS	FORTIFLEX RESINS A-20	A-70	A-250	A-500
Melt Index	D-1238-52T	—	0.2	0.7	2.5	5.0
Heat Distortion Temp. (66 psi)	D-648-45T	°F.	185	185	180	180
Brittleness Temp.	D-764-52T	°F.	—200	—180	—160	—100
Impact Strength, izod (⅛" x ½" injection-molded bars)	D-256-54T	ft. lb./in. notch	23	18	13	3
Tensile Strength, Max., 0.2 in./min.	D-638-52T	psi.	3700	3600	3500	3300
Elongation, First Tensile Yield Point	D-638-52T	%	25	25	25	25

Properties of Fortiflex "A" Not Affected by Melt Index

PHYSICAL PROPERTIES	ASTM METHOD	UNITS	VALUE
Density		g/cc.	0.96
Refractive Index	D-542-50	n_D^{25}	1.54
Hardness, Shore D	D-676-49T		65
Stiffness	D-747-50	psi.	130,000
Water Absorption (⅛" specimen, 24 hr. immersion @ room temp.)	D-570-54T	%, wgt. gain	<0.01
Flammability	D-635-44	in./min.	1.0
*Mold Shrinkage, length		in./in.	0.03 to 0.05
width		in./in.	0.02 to 0.04

*Measured on injection molded tensile bar. Mold shrinkage depends on part design and molding conditions.

Celanese Plastics Company, a Division of Celanese Corporation of America
Dept. 129K 744 Broad Street, Newark 2, N. J.

Please send: ☐ more information on, ☐ test quantities of Fortiflex.

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Company _____

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M&T Products for plastics

Thermolite® ORGANOTIN Stabilizers

Used alone for unmatched performance in optical clears, or synergistically to greatly boost the stabilization characteristics of less effective stabilizers.

Thermolite Organotins are the first choice for premium crystal clarity in PVC — and are often the successful last resort when other stabilizers fail under difficult processing conditions.

FOR ULTRA-HIGH TEMPERATURE STABILITY
in the processing of rigids and semi-rigids

Thermolite 31—Processing at 350 F and above is practical with this stabilizer. Unexcelled for clear or pigmented rigids.

Thermolite 20—Lubrication is built into the molecule of this organotin. For use alone or with Thermolite 31, as lubrication requirements dictate.

FOR VERY-HIGH TEMPERATURE STABILITY

Thermolite 13—Outstanding light stability and excellent heat stability are contributed by an organotin-dienophilic combination in the molecular structure. Particularly suitable for plastisols, rigids, semi-rigids and blending with other Thermolites.

Thermolite 17—Combines the heat stability of the dienophilic Thermolite 13 with the high-lubrication of Thermolite 12. An ideal stabilizer for calendering and extrusions.

Thermolite 12—Outstanding light stabilization and excellent lubrication augment good heat stability. These properties plus ready solubility in plasticizers make it unusually useful for plastisols and organosols.

Thermolite 45—Low-cost organotin for calendering and extrusion. Eliminates clouding in garden hose and other clear PVC's exposed to water.

FOR ALL-PURPOSE ORGANOTIN STABILIZATION

Thermolite 25—Widely used in plastisols because of its excellent heat and light stability and is especially valuable in slush molding where it gives no plate-out problems.

Thermolite 26—A self-lubricating stabilizer with good heat and light stability, especially recommended for calendering vinyl copolymers for decorative sheeting, etc.

Thermolite® LIQUID Ba-Cd Stabilizer

A unique, new concept in Ba-Cd stabilizers for low-cost processing clarity and outstanding light stabilization.

Thermolite 112—A completely aromatic-based, low-volatility stabilizer giving crystal clarity and excellent light stability. Soluble in all plasticizers this Ba-Cd stabilizer overcomes plate-out in calendering and extrusions.

Thermolite® AUXILIARY Stabilizers

...Designed to augment the compounding and performance characteristics of the primary stabilizers.

Thermolite 166—A liquid-zinc stabilizer used in conjunction with Ba-Cd types to improve initial color, reduce plastisol viscosity and overcome sulfur staining.

Thermolite 180—An antioxidant-stabilizer of purely organic composition for use with all metal stabilizers to improve light stability, help overcome plate-out, and prevent yellowing during processing.

CATALYSTS Urethane Foam

A complete line of catalysts used in one-shot urethane foam systems.

CATALYST T-12 (Dibutyltin dilaurate)
CATALYST T-8 (Dibutyltin di-2-ethyl hexoate)
STANNOUS OCTOATE
STANNOUS OLEATE

M&T FLAME RETARDERS

...For incorporation in PVC and other chlorine-containing films and coatings to provide "non-inflammable" characteristics.

M&T Thermoguard* H—High tinctorial strength antimony oxide for whites and pastels where it contributes useful white-tinting strength.

M&T Thermoguard* L—Low tinctorial strength antimony oxide a minimum opacity antimony oxide particularly suitable for deeper colors.

M&T Flame Retarder—An antimony-based flame retarder that has one-fifth the tinting strength of antimony oxide and designed for semi-transparent plastics or those containing high-cost pigments and toners.

*Trade Mark

For information on any of these products write to:

M&T Chemicals

METAL & THERMIT Corporation, Rahway, N. J.

Sn Sb P Si Ti Zr inorganics and organometallics

U.S.I. POLYETHYLENE NEWS

A series for plastics and packaging executives by the makers of PETROTHENE® polyethylene resins

Packaging Notes

A low-cost, semi-automatic bagging machine puts canned and bottled goods in preprinted polyethylene bags to stimulate larger unit sales to the consumer.

A brewery, for example, has increased its sales by replacing its conventional six-pack with an eight-can bagged unit. Quart bottles are bagged in units of three. As an added consumer advantage, the polyethylene bags can be filled with ice to keep the beer cold. The bagging machine can be used to package such canned and bottled products as soft drinks, soups, juices, and dog foods.

A new polyethylene and paper pouch for liquid bleach has been introduced. This disposable pouch for coin laundries holds 2½ ounces of highly corrosive 15% sodium hypochlorite. It is expected to replace the present eight ounce returnable bottles which hold 5% sodium hypochlorite.

The pouch is constructed of paper coated with 3½ mil polyethylene film. A special tear tape at one end permits opening of the package quickly and easily. The package reportedly is lower in cost. It has a shelf-life of six months.

Containers with built-in polyethylene coated paper liners are being used by a frozen foods company to package a portion of its frozen fruits.

Designed to eliminate the conventional overwrap, the new package is said to prevent leakage of the package's contents both before freezing and after defrosting. Liner and carton flaps are automatically sealed, with a combination of polyethylene heat sealing and adhesive.

The new package is more convenient to open than previous metal and fibre cans. Its special interlocking top flaps can easily be ripped off by the consumers without danger of spilling the contents. The new polyethylene lined carton stacks better and provides more printing area. It reportedly has reduced packaging costs and increased packaging speed.

Ralph Knight Appointed Vice President at U.S.I.

Ralph M. Knight has been appointed a Vice-President at U.S. Industrial Chemicals Co. The new appointment was announced by Dr. Robert Hulse, General Manager of the U.S.I. Division.

Mr. Knight will be responsible for long range planning and coordination of U.S.I.'s polymer development program. He will continue to direct the company's Polymer Service Laboratory as well as coordinate its efforts with other plastic activities in the company. Mr. Knight joined U.S.I. in 1953 as Polyethylene Manager. He is a graduate of Newark College of Engineering.

U.S.I. Plans 50 Million Pound Polyethylene Resin Expansion

Latest Increase Will Make U.S.I. World's Second Largest Producer

U.S.I. has announced plans for a new increase in production capacity of PETROTHENE polyethylene resins — this time 50 million pounds. The planned expansion will be at U.S.I.'s new Houston plant started up in February of this year. This plant, currently being upped from 75 to 150 million pound production per year, will be still further expanded to produce 200 million pounds.

This is part of U.S.I.'s new polyethylene plant located at Houston, Texas, at the time that finishing touches were being made on product silage units last spring. Originally built with an annual capacity of 75 million pounds, the plant is currently being upped to 150 million pounds, will have a final capacity of 200 million pounds, when further expansion is complete next year.

The expansions are expected to be complete by mid-1960, giving U.S.I. an overall production capacity of 300 million pounds annually. This will make the company the second largest among all polyethylene producers in the world.

Growth Has Been Spectacular

U.S.I.'s growth in the polyethylene field has been spectacular. Starting with a production capacity of 26 million pounds in 1955, the company will have realized increase in production of well over 1000% when the expanded facilities go on stream.

Along with this growth has come technical leadership in the field of polyethylene processing, particularly in packaging film. Eighteen months ago, U.S.I. pioneered a new technique for producing crystal-clear cast polyethylene film that is finding extensive application in large volume overwrap and bread wrap markets. While U.S.I. has specialized in low and medium density resins, it has done extensive research work on a new process for making high density polyethylene. The process is said to be superior to any now in use. U.S.I. also is studying the polypropylenes and other polyolefin copolymers in pilot plant operations.

Wide Range of Resins Available

In all, PETROTHENE polyethylenes are available in some 70 different resins, each varying in melt index, density, strength, clarity, gloss, slip, stiffness, and other properties. This wide range of resin properties is a result of U.S.I.'s program of tailor-making resins to meet specific molding and extrusion requirements.

Polyethylene Netting Made With Special Extrusion Die

A new polyethylene netting, extruded from a special reciprocating die, promises to have many decorative and practical applications. The die cross extrudes the polyethylene filaments, welding them together at point of contact while the resin is still molten. The filament junctions are stronger than is possible with heat sealing.

Both decorative and practical applications are foreseen for continuous tubular netting like this which is now being produced.

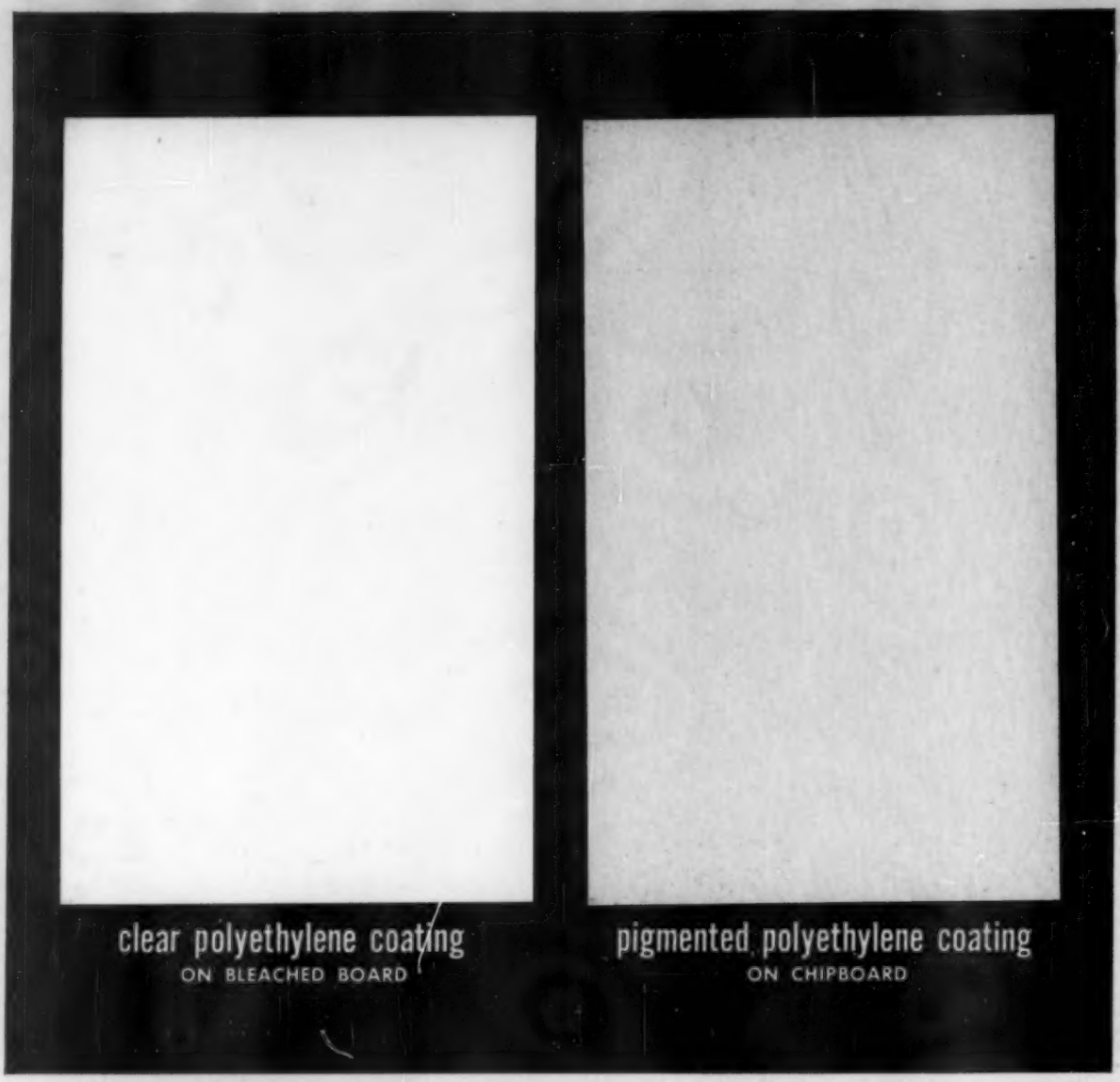
At present the net can be produced in widths up to 36 inches and in tubular form. Multicolored effects can be obtained and the mesh can be varied from very fine to fish-net coarseness.

The manufacturer is now developing an automatic bag machine for packaging vegetables and other produce.

New Ultraviolet Absorber For Polyethylene

A new ultraviolet absorber for polyethylene is currently being evaluated. Thus far, carbon black has been the most commonly used screen for ultraviolet light.

The new compound, if successful, will permit extended outdoor use of clear and colored polyethylene compounds. Field tests have already shown that 10-mil polyethylene film mixed with .171% by weight of the absorber, retained 85% of elongation after two months use in strong sunlight.



THE CHOICE IS UP TO YOU . . .

You know about polyethylene-coated board and the wonderful job it's doing in the food and industrial packaging fields. But do you know about *pigmented* polyethylene coatings and how they can upgrade lower-priced board, allowing you to choose from a wider range of board stock and to achieve even greater flexibility in your choice of packaging materials.

Investigate both kinds of polyethylene coatings; you'll find they're more versatile than ever before.

Clear or pigmented—extruded polyethylene coatings are tough, scuff resistant, unusually adherent. They have superior grease and moisture resistance. They will not scratch other surfaces. They heat seal readily, offer good printability.

Extruders and packagers who make or use polyethylene-coated board may obtain information and technical assistance by writing to U.S.I.

EXTRUDERS—

PETROTHENE® polyethylene extrusion coating resins, manufactured by U.S.I., have good drawdown properties with a minimum of neck-in, give excellent adhesion even down to the thinnest gauges.

U.S.I. INDUSTRIAL CHEMICALS CO.
Division of National Distillers and Chemical Corp.
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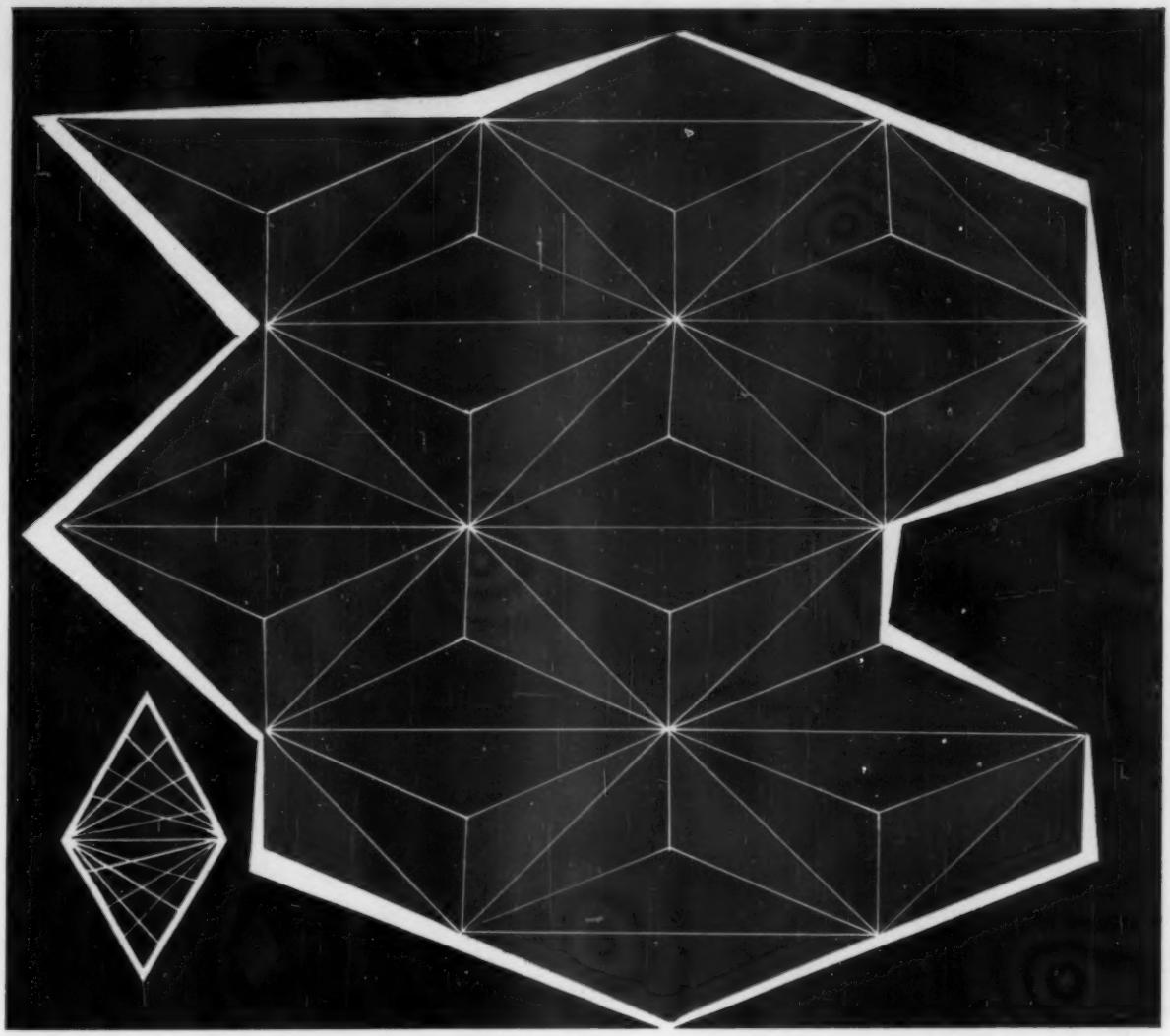

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MORE ON-STREAM TIME WITH HARTIG

All Hartig research and development has been directed toward greater production efficiency. Today, Hartig extruders are known for their high production rate; ease of set-up, start-up and purging; for automatic operation requiring less skilled manpower; and for the fine control essential to precision extrusion and quality.

Hartig extruders and matched auxiliary equipment are ruggedly built to stand up for long continuous runs with minimum down time for maintenance.

As a result, in shops equipped with Hartig and one or more other makes, you will usually find Hartigs logging more production time. We will be glad to give you facts and figures on Hartig equipment for your operation.

Send for your copy

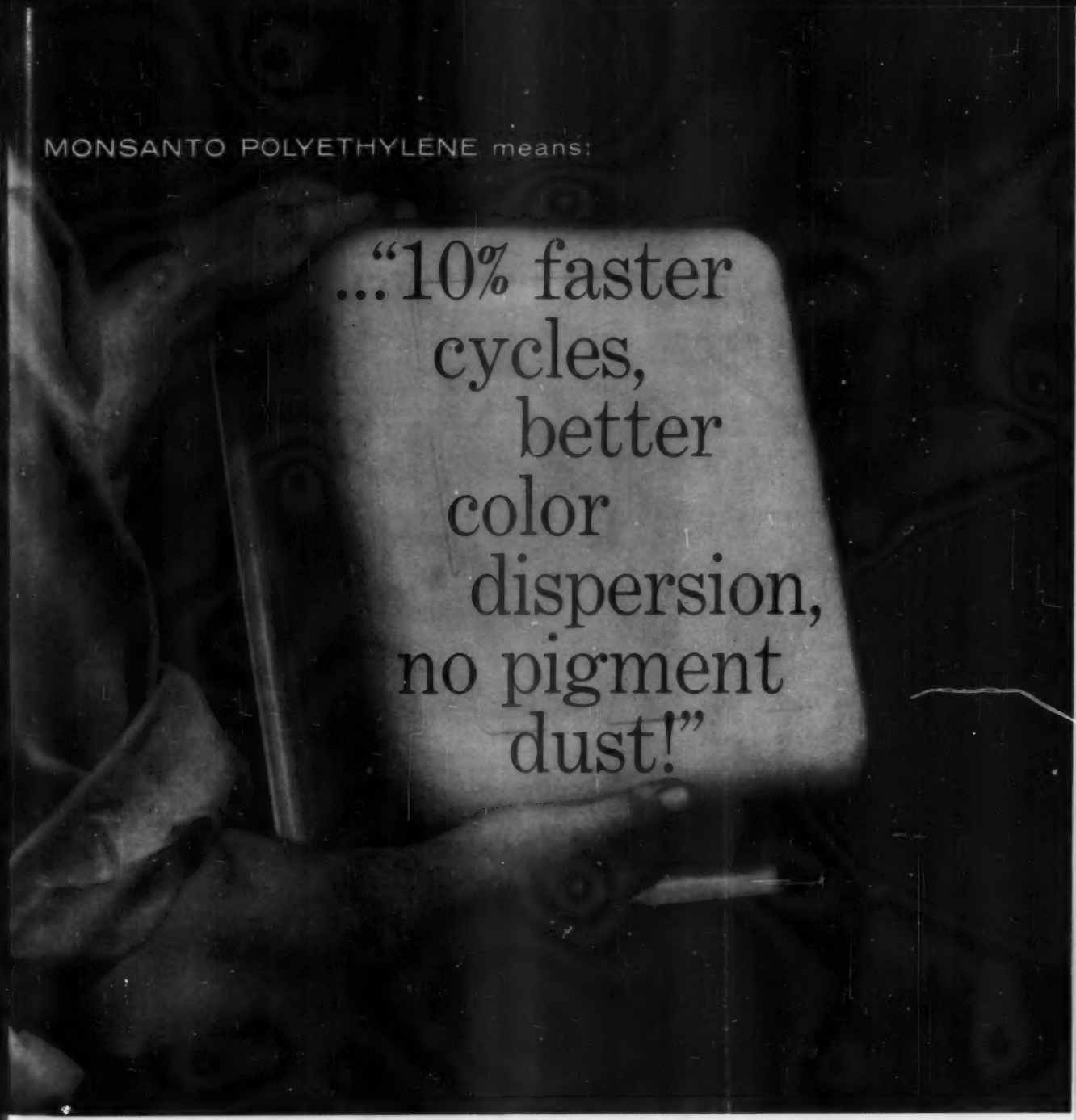
of the new illustrated booklet describing the line of Hartig Extruders and Matched Auxiliary Equipment.

HARTIG EXTRUDERS

Division of Midland-Ross Corporation
MOUNTAINSIDE, NEW JERSEY

Hartig 4½" extruder, 24:1 L/D, with sheeting die.

Effective Screw Length: 108¼"
Nominal Capacity: 350-450 lbs./hr.
Barrel Heat: 19 bands, 3200 W ea.
Control Zones: barrel, 4 (standard)
Temperature Controls: 4 (proportioning)
Thrust Bearing Capacity: 299,000 lbs.
Floor Dimensions: 203" x 82"
Weight (approx.): 8500 lbs.
Motor Drive: 50-75 hp. (standard)



Plastic Engineering Inc., Cleveland, Ohio, reporting:

"The bag-to-bag, blend-to-blend, big batch uniformity of Monsanto Polyethylene 9752 enabled us to slice 2 seconds per part off our cycle time. With dishpan production in the thousands, this reduction is appreciable.

"In addition, we can now maintain uniform color throughout an entire run—a definite sales-plus. Before switching to Monsanto Polyethylene, pigmented material dust, during dry coloring, was a serious problem. During press runs, dust would escape and literally cover everything in the area. To keep foreign elements from getting in a batch and streaking the products, we had to wash down the presses between runs. It even became a morale problem, which our change to Monsanto Polyethylene has happily solved.

"One last, but not least, factor is the convenience of disposable palletized shipments. It has reduced unloading and stacking time from 3 men in 2 hours to one man in a lift truck for a half hour."

The complete line of Monsanto Polyethylene Molding Resins is described in detail in our new composite data sheet. Write for a free copy of this folder to Monsanto Chemical Company, Plastics Division, Room 1126 Springfield 2, Massachusetts.

Monsanto

DOW **Plastiatrics**

DOW'S CLINICAL APPROACH TO HEALTHY PLASTICS APPLICATION

NEW EPOXY SYSTEM MAKES ADVANCED TV TUBE DESIGN PRACTICAL

DOW DEVELOPMENT CAPITALIZES ON EPOXY'S GLASS ADHESION, STABILITY, CLARITY

A leading TV tube manufacturer recently presented Dow with a problem involving the laminating of glass panels. They had developed an advanced design for a square-face TV tube which required the laminating of a contoured implosion safety panel directly to the face of the tube. The design would provide greater safety against implosion, produce a brighter picture, eliminate the conventional, dust-catching, separate safety panel and permit the building of slimmer sets. To accomplish this, the manufacturer required a special laminating system and resin material which would meet the following requirements:

1. The method must be adaptable to mass production.
2. The method must provide a stable, adhesive bond to glass.
3. The resulting laminate must be able to withstand rough handling.
4. The resulting laminate must be able to withstand extreme changes in humidity and temperature.
5. Resulting optical properties must be acceptable by E.I.A. color standard for television.

Because no available resin met all these requirements, Dow had to develop a special system which would solve the problem.

Dow's prior extensive research and development work on epoxy resins, coupled with Dow's basic raw material position, had produced new resins whose properties appeared to offer promise of fulfilling the stated requirements. Among these resins were several which were known to: provide high-strength bond to glass; produce stable, heat-and-shock resistant laminate interlayer; exhibit nearly water-white clarity after cure; cure quickly at relatively low temperatures.

DOW EPOXY RESINS

Liquid Resins—For casting, laminating and adhesives

D.E.R.* 332—Nearly water-white
D.E.R. 331—Coatings and laminating
D.E.R. 334—Lowest viscosity

Solid Resins—For Pre-preg and Coatings.

D.E.R. 661—Nearly water-white—Amine cure.
D.E.R. 667—Nearly water-white—Maximum hardness
D.E.R. 664—Epoxy esters

Dow Epoxy Novolacs

Thermosetting epoxy resins for high temperature use—up to 500° F.

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Working closely with TV engineers and manufacturers of automatic blending and dispensing equipment, Dow chemists and technical service engineers tailored a unique epoxy system which met every requirement for successful mass production of the new square tube.

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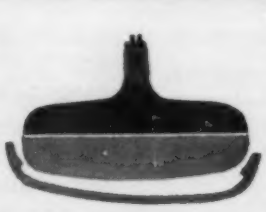
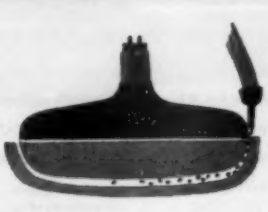
Panel and tube faces are cleaned and preheated (150-200° F.)



Preheated parts are assembled and positioned properly.



Resin system is automatically injected, cures to handle in fifteen minutes.

THE DOW CHEMICAL COMPANY · MIDLAND, MICHIGAN

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PLASTIC FOAMS - A DIRECTORY

The market structure for plastic foams is dominated by three materials - polystyrene, urethane, and vinyl. These three foams, along with phenolic, which is still a small-volume, development material, share the major foam applications today. Remaining plastic foams, either because of economic or physical properties, are currently restricted to specific small-volume areas of application. The following description of the various foams will give a quick picture of how they are made, in what form are they supplied, and what are their uses.

C. R. Davall,

Union Carbide Plastics Co., Division of Union Carbide Corp.

Phenolic

DESCRIPTION:

Thermoset cellular solid, density controlled by formulation, with densities of 1/3 lb/ft³ to over 10 lbs./ft³ possible.

ADVANTAGES:

Ease of foaming in large scale industrial equipment, good heat resistance (under certain conditions up to 400°F.) and can be made self-extinguishing without use of additives, has good dimensional stability and solvent resistance.

DISADVANTAGES:

Non-resilient, only fair mechanical strength, permeable, requires a seal at vapor barrier.

HOW SUPPLIED:

As high solids solution of resin in water.

HOW PREPARED:

Addition of catalyst results in foaming and curing of resin. Reaction provides heat required.

USES:

Thermal insulation and floral packaging applications.

Polystyrene

DESCRIPTION:

Closed-cell, density 1-10 lb/ft³

ADVANTAGES:

Low water-vapor transmission, toughness, semi-resilient

DISADVANTAGES:

Inflamability (though self-extinguishing grade is available), thermoplastic

HOW SUPPLIED:

Prefoamed sheets, planks and boards, and as tiny granules which can be expanded and fused in molds into plank or other form.

HOW PREPARED:

Granules are expanded in molds by application of external heat.

USES:

Perimeter, pipe and freezer insulation, sandwich panel core, packaging, plaster base, decorative novelties.

A Very Unusual Foam

A highly unusual variety of phenolic foam, which is not really a foam at all in the conventional sense of the word, is syntactic foam. The syntactics have the unique advantage of being a "prefabricated" foam because their cell structure does not depend on any chemical reaction but on premade hollow spheres of microscopic size filled with an inert gas. These spheres resemble soft red flour and are combined with either polyester or epoxy resin to form a putty-like material that cures with or without the application of heat to a strong, light-weight solid. The relative simplicity with which syntactic foam can be prepared has led to its use as a do-it-yourself material for minor repairs of rotted-out wood structures. Irregular areas which require a foamed-in-place type material not involving a chemical reaction are accessible to this type foam since it can be troweled or otherwise handworked into difficult corners. This adaptability has also suggested syntactics for such applications as aircraft wing structures, some type of reinforced plastic boats, and refrigerator castings.

Vinyl

DESCRIPTION: Can be made either flexible or rigid, closed or open cell structure.

ADVANTAGES:

Does not support combustion, can be heat-sealed to other materials thus reducing cost of trimming and adhesive operations, low water vapor transmission. Flexible type has high strength and toughness.

DISADVANTAGES:

Mechanical properties deteriorate above 140°F., resilence is reduced at temperatures below −20°F.

HOW SUPPLIED:

Sheets, slabs, molded cushions.

HOW PREPARED:

Most popular method utilizes Elastomer process, a mechanical technique for producing an open-celled flexible foam. An inert gas such as CO_2 is mixed with a vinyl plastisol at a pressure of 300-500 p.s.i. When this mixture is released to normal atmospheric pressure through a nozzle or tube, it foams.

USES:

Rigid-insulation, flexible-comfort cushioning, padding, and flotation.

Urethane Foams

DESCRIPTION:
Can be made in either flexible or rigid state. Density controlled by amount of water and excess polyisocyanate used.

ADVANTAGES:
Flexible urethane foam has good cushioning properties, tensile strength, Rigids can be made with very low K factor.

DISADVANTAGES:
Some grades are flammable and/or have only fair dimensional stability.

HOW SUPPLIED:
100% solids liquid materials.

HOW PREPARED:
Exothermic reaction of liquid components generates foam and hardens resultant polymer.

USES:
Flexible-comfort cushioning, rigid-thermal insulation, structural core material.

Polyethylene Foam

DESCRIPTION:
High density (about 35 lbs./ft^3), semi-rigid foam.

ADVANTAGES:
Electrical properties remain constant at high frequencies and material permits a considerable reduction in cable size and weight. Has good moisture resistance and economical production on conventional extrusion equipment.

DISADVANTAGES:
High density

HOW SUPPLIED:
As extrusion compound

HOW PREPARED:
Extruded

USES:
Cable insulation.

Epoxy Foams

DESCRIPTION:
Rigid, closed cell, thermoset foam.

ADVANTAGES:
Tough, good electrical properties, good adhesion, and ability to be foamed-in-place.

DISADVANTAGES:
High price

HOW SUPPLIED:
Prefoamed blocks or foamable liquids

HOW PREPARED:
Mixture of two reactive, liquid components which generates foaming action and heat required to harden foam.

USES:
Potting and encapsulation of electrical components and tool checking fixtures or other tool and die parts for which their specific properties make them suitable.

Silicone Foams

DESCRIPTION:
Open cell, thermoset, rigid foam

ADVANTAGES:
Outstanding high-temperature resistance—useful at 500-700°F.

DISADVANTAGES:
High cost.

HOW SUPPLIED:
Foamable powders

HOW PREPARED:
Application of external heat results in foaming and cure of resin.

USES:
Only where outstanding high temperature resistance is needed or outstanding electrical properties are needed.

Cellulose Acetate Foam

DESCRIPTION:
Closed cell, rigid foam

ADVANTAGES:
Considerable toughness, easily machined.

DISADVANTAGES:
Low softening point, comparatively high cost.

HOW SUPPLIED:
Prefoamed boards and rods

HOW PREPARED:
Extrusion of resin melt

USES:
Structural core material, flotation devices, packaging material.

Table I. Properties of Various Rigid Foams

Foam Sample	"K" Factor	Moisture Vapor Transmission	Percent Closed Cells	Flame Propagation Rate	Tensile Modulus psi	Tensile Strength psi	Tensile Elongation	Change in Strength After Humidity Aging	Friability
See notes below	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Molded Vinyl	0.23	1.2	78	0	1900	73	9	-	0
Molded Vinyl	0.23	0.9	84	0	2700	140	10	-	0
Polystyrene	0.26	1.8	78	8	2500	60	4	0	2%
Polyurethane	0.24	4.8	79	32	1500	60	5	−40	35%

Notes:

(1) "K" B.T.U.—in./Hr. sq. ft. °F Mean Temperature 40°C. Temp. Diff. 40°C.
(2) Perm-inches.
(3) Air Displacement Method.
(4) At 100°C.
(5) (6) (7) At 23°C.
(8) Aged at 70°C and 80% Relative Humidity.
(9) Tumbling Friability (ASTM C-367).

* All foam samples tested were in the 2-lb./ft.^{3} density range.

By the proper choice and use of catalysts, significant improvements in cushioning properties of polyester urethane foam can be made. Tertiary amine catalysts having a beta amino ethoxy structure were found to give foams with superior resiliency.

Tertiary Amine Catalysts: How They Affect Foam Properties

By G. T. Gmitter, E. E. Gruber, and R. D. Joseph,

Central Research Laboratories, General Tire & Rubber Company

Adipate polyester urethane foams are made by the simultaneous combination and mixing of a polyester, tolylene diisocyanate, and an activator. The polyester most used is a polydiethylene glycol adipate with hydroxyl end groups and a few percent of a triol, e.g., trimethylolpropane, to provide some branching in the polyester. The activator component generally consists of a tertiary amine catalyst or catalysts, water and mixtures of non-ionic and anionic surfactants. While the activator in some cases may be first combined with the polyester prior to its mixing with the tolylene diisocyanate (TDI), the basic formulations are still similar.

In general, such polyester urethane foams have been found unsatisfactory for cushioning applications, primarily because of poor seating comfort and poor humidity aging. The effects of foaming catalysts on humidity aging of foam have been discussed previously by Winkler[1].

While seating comfort and "feel" are subjective values and not readily defineable, it is generally believed that a numerical evaluation may be somewhat satisfactorily derived from a study of load deflection and resiliency. Standard polyester urethane foams, while exhibiting fairly high resiliency values at first, tend to drop in resiliency upon flexing or loading, so that final resiliency values may be as much as 50 percent lower than the original values. This loss in resiliency contributes to its undesirability as a cushioning product. *Figure 1* (page 958) shows the stress-strain behavior of the usual polyester urethane foam. The "plateau" apparent at about 50 percent deflection points out the peculiar cushioning characteristics of polyester foams. This foam has an initial high modulus which gives it a harsh feel. A slight additional load deflects the foam to a high percentage of its original height (plateau effect) which produces a sinking feeling.

In an attempt to improve seating comfort in the standard polyester foam considerable emphasis was placed on an exploration of the tertiary amine catalysts. The various tertiary amines investigated were found to fall into three groups. The following classification is based on the effects which these catalysts produce on cushioning properties.

GROUP A

- **Tri-n-propylamine**
- **Tributylamine**
- **Triamylamine**
- **Trihexylamine**
- **Alpha-methyl benzyl dimethylamine**
- **m-Diethylaminophenol**
- **N,N-Diethylcyclohexylamine**
- **Dimethyl "coco" amine**
- **Dimethyl "C18" amine**
- **3-N-Diethylamino-1-propanol**
- **5-N-Diethylamino-2-pentanol**

GROUP B

- **Dimethylaminoethanol**
- **Diethylaminoethanol**
- **Diisopropylaminoethanol**
- **Dibutylaminoethanol**
- **Ethyldiethanolamine**
- **Isopropyldiethanolamine**
- **Butyl diethanolamine**
- **m-Tolyldiethanol amine**
- **2-N-Ethyl anilinoethanol**
- **1-Amino-3-diethylamino-2-propanol**
- **2-Di-n-butyl-N-amino-1-propanol**
- **3-Dimethyl amino-1,2-propanediol**
- **1-Diethyl amino-2-propanol**
- **Benzylmethylaminoethanol**
- **1-Dimethylamino-2-propanol**
- **Diethylaminoethoxyethanol**
- **o-Tolyl propanolamine**
- **Tetrahydroxyethylenediamine**
- **Phenylethylaminoethanol**
- **N-Hydroxyethyl morpholine**

GROUP C

- **N-Methyl morpholine**
- **N-Ethyl morpholine**
- **N-Octyl morpholine**
- **N-"coco" morpholine**
- **N-Hydroxyethyl morpholine**
- **N-Acetyl morpholine**
- **4,4'-Dithiomorpholine**
- **N-Phenyl morpholine**
- **Di-(Diethylaminoethyl) adipate**

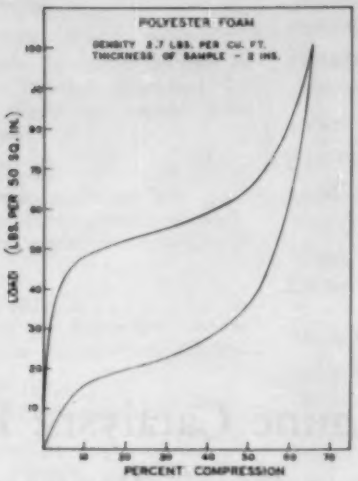

Figure 1. Stress-strain behavior of polyurethane foams.

Evaluation formula for the above amines follows:

80 parts by weight polyester

24.5 parts by volume tolylene diisocyanate (65/35 or 80/20, 2,4/2,6 isomers)

1.6 parts by weight water

1.0 parts by weight non-ionic emulsifier

0.1 parts by weight anionic emulsifier

0.5 to 1.5 parts by weight amine.

The polyester used was a polydiethylene glycol adipate of the type described above with a hydroxyl number of 60, and an acid number of 1.0. Its viscosity at 28°C. was 12,-900 cps.

The nonionic emulsifiers in these formulations were generally polyethoxylated phenols or alkyl phenols. These were selected for their water solubility, stability to alkali, and for their neutrality in water solution. Sodium dioctyl sulfosuccinate was the most common anionic used, although sodium N-cyclohexyl-N-palmitoyl taurate was equally effective. Selection of the anionics was guided by the same specifications set up for the non-ionics.

The three groups of amines indicated above varied in activity as determined by the time of foam rise. No attempt was made to limit the time interval for foam rise by a particular amine level in the formulation. Foam densities thereupon varied from 2.5 to 5.5 lbs. per cu. ft. depending upon the activity of the particular amine used and its concentration. Some of the amines evaluated are solids at normal temperatures and insoluble or only slightly soluble in water. These were first melted and/or dispersed in the water together with the emulsifiers to obtain an emulsion which was used directly.

These amines were evaluated in foam formulations both by mixing in a container with an air stirrer and by use of a small mechanical foam machine. The resulting foams were all cured for a period of twelve hours at temperatures of 100-110°C.

Density, compression set, load deflection, resiliency and hydrolytic aging were the properties determined on the cured foams. Greatest emphasis was placed on resiliency values which were determined by the Schopper method which uses a pendulum type of tester giving direct readings on a scale ranging from 0 to 100.

The amines listed in Group A by the above classifications produced foams which initially exhibited high or moderate Schopper rebound values. Subsequent wringing of these foams between rubberized rolls providing 90-95 percent compression resulted in a considerable drop in rebound values. As shown in Table I, in many instances, this reduction in rebound was more than 50 percent of the original values. Five to ten passes through the rolls were often sufficient to bring about this change. All rebound values were determined under constant temperature and humidity conditions with two or more hours elapsing between the time of wringing and the rebound determination. Using the Schopper test, resiliency values for latex foam are in the 60-65% range.

TABLE I. Catalysts from Group A Produced Foams of Initially High Rebound Values

Amine	Amount in* Formulation	% Rebound OW	5W**	20W	35W
Dimethyl "coco"	1.0	55	22	21	23
	1.5	54	34	28	23
Dimethyl "C18"	0.5	47	25	27	27
	1.0	40	30	26	23
Tri-n-propyl	1.0	26	16	13	13
	1.5	32	12	10	12
Tri-n-butyl	0.5	25	24	20	17
	1.0	27	12	12	12
	1.5	32	13	12	10
Tri-n-amyl	1.0	26	23	20	15
Tri-n-hexyl	0.5	32	20	17	17

* = Parts per 80 parts Polyester
** W = Passes through rolls

The above resiliency values are typical of the Class A (trialkyl tertiary amine) catalysts in this polyester foam system. Wringing of any sort tended to reduce the original resiliency values considerably. While wringing also reduced the foam modulus, this softening coupled with the low resiliency values produced a "dead feel" in the foams with more pronounced "bottoming" characteristics.

Group A catalysts would not produce desirable polyester urethane cushioning since normal flexing would bring about the effects observed through wringing.

The tertiary amine catalysts found in Group B may be characterized by their common beta-amino ethoxy structure. Practically all of these amines possess the oxygen atom as part of a hydroxy grouping. As a class, these tertiary amines were generally less active than those of Group A as determined by the time of foam rise. Unlike the amines in Group A, these beta aminoethanol catalysts produced foams whose rebound values tended to increase or remain constant with wringing. At no time, with any of these amines, was a definite decrease in resiliency observed. Some rebound values of foams based on Group B catalysts are listed in Table II.

The softer foams resulting from wringing together with the high resilience gave the above foams a "bouncy" feel.

The tertiary amines in the Group C classification are related by virtue of their common morpholine ring. This provides the beta amino ethoxy structure as well, so that they, too, have in common the structure found in Group B.

TABLE II. Rebound Values of Foams Based on Group B Catalysts

Amine	Amt. in Formula*	% Rebound 0W	5W**	20W	35W
Diisopropyl-aminoethanol	0.5	33	38	38	40
Diethylamino-ethoxyethanol	1.0	33	36	35	36
Dibutylaminoethanol	1.0	34	44	44	43
	1.5	37	42	42	42
Di-(diethylamino-ethanol) adipate	1.0	35	43	43	42
	1.5	33	43	42	43
Butyldiethanolamine	0.5	44	44	44	44
	1.0	44	45	43	44
	1.5	48	49	47	47
Ethyldiethanolamine	1.0	44	45	44	44
	1.5	44	43	42	44
1-Dimethylamino-2-propanol	0.5	34	36	40	40
Tetrahydroxyethylene diamine	0.5	42	42	42	43
o-Tolylpropanolamine	1.0	45	43	44	44

* Parts per 80 parts Polyester
** W = passes through rolls

TABLE III. Nitrogen Alkylated Morpholines Produce Foams with Rebound Tendencies Similar to those Based on Group B Foams

Amine	Amt. in Formula*	% Rebound 0W	5W	20W	35W
N-"coco" morpholine	1.0	47	44	46	45
	1.5	46	44	44	44
N-Octylmorpholine	1.0	45	45	45	45
	1.5	43	42	41	42
N-Hydroxyethyl-morpholine	1.0	49	48	48	48
	1.5	48	48	46	46
N-Acetyl Morpholine	1.0	34	34	36	37
4,4'-Dithiomorpholine	1.0	35	37	38	39
N-Methylmorpholine	1.0	31	30	30	30

* = Parts per 80 parts Polyester
W = Passes through rolls

Like the Group B catalysts, these morpholine derivatives result in foams which show an increase or no significant change in resiliency upon severe wringing.

Since humidity aging tests are important indicators of expected service life for urethane foams, many of the foams based on catalysts in Group B and C were exposed to humidity conditions at elevated temperatures. The effects of humidity exposure on foams formulated with some of the catalysts discussed herein are tabulated with respect to load deflection changes in Table IV. Samples were exposed to high humidity in a Hudson Bay cabinet using one of the early test procedures of round robin testing by the S.P.I. Sub-committee on Test Methods for Urethane Foam. Three samples of commercial polyester foam obtained for the round robin test are listed in Table IV.

TABLE IV. Humidity Aging—Seven Days at 95-100% RH, 180°F.

Catalyst	% Change in 25% Load Deflection
Isopropyldiethanolamine (Group B)	−20.7
Dibutylaminoethanol (Group B)	−16.4
Diethylamino-2-propanol (Group B)	−19.5
N-"coco" morpholine (Group C)	−38.6
N-Methyl morpholine (Group C)	−24.6
Di (diethylaminoethyl) adipate (Group B)	−48.4
Commercial Polyester Foam #1	−37.0
Commercial Polyester Foam #2	−37.6
Commercial Polyester Foam #3	−48.5

The aging of foams based on the morpholine derivatives (Group C) are generally poor. Undoubtedly, the residual amine in the foam serves to catalyze the hydrolysis of the polyester fragments under the influence of humidity and elevated temperatures.

The three beta amino ethanol catalysts in Table IV show a marked improvement in humidity aging stability. While numerous data are available to show the improved hydrolytic stability of other aminoethanols, they were not included because of the variety of test conditions used in their evaluation. However, all data indicated that foams based on the beta amino ethanol type catalysts (Group B) showed the best hydrolytic aging results. Presumably during foaming, the hydroxyl end groups allow a partial tie in of the catalyst into the foam structure and thus the later depolymerization activity in the presence of humidity is effectively reduced.

The classification of amine catalysts used in this work is purely arbitrary and is based on rebound performances of their foams after wringing, as well as common structural features in the amines. Both Groups B and C have in common the beta amino ethoxy structure. In Group B, this structure is also part of the hydroxyl moiety which results in improved humidity aging resistance. Group A is more heterogeneous and contains those amines which do not produce good resiliency in their foams after wringing. Some of the catalysts in Group A are tertiary amino alcohols with the amino groups in the gamma or delta position with respect to their hydroxyl groups. These, like the catalysts in Group B, result in foams with improved hydrolytic stability. None of the catalysts in Group A, however, possess the beta aminoethanol structure which gives both, improved hydrolytic stability, as well as good rebound characteristics in their foams. In every instance, catalysts having the beta amino ethoxy structure (Groups B and C) were found necessary to prepare foams with superior resiliency.

The wringing of foams based on morpholine type catalysts also results in foams with lower modulus. Like the Group B catalyst foams, these foams exhibit a better "feel", less plateau in their loading and unloading curves, and better flexing characteristics when compared to the usual polyester urethane foams.

Figure 2 illustrates one of the loading and unloading curves in foams produced with the catalysts under discussion. The plateau present in the usual polyester urethane foam represented by the dotted lines has been reduced considerably. The drift on loading of the foam at any deflection also is at a minimum and the feeling of continually sinking into the cushion has been almost eliminated.

Flexing tests conducted on these foams indicate better and longer service of these foams can be expected. The data in Table V compares foams prepared with catalyst from Groups B and C with a standard polyester urethane foam and latex foam.

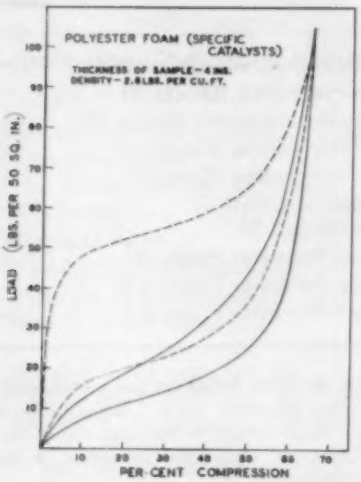
POLYESTER FOAM (SPECIFIC CATALYSTS)
THICKNESS OF SAMPLE – 4 INS.
DENSITY – 2.8 LBS. PER CU. FT.
LOAD (LBS. PER 50 SQ. IN.)
PER CENT COMPRESSION

Figure 2. Loading and unloading curves.

TABLE V. FLEX TESTS

Type Foam And Density	Sample Dimensions	Time Interval After Flexing	% Decrease in Deflection	% Set
Latex foam	12" x 12" x 2"	Immediate	19	2.0
Actual Dens.	uncored	1 hour	16	1.0
7.0 lbs./cu.ft.		10 days	10	0.5
Regular	12" x 12" x 4"	Immediate	45	4.1
Polyester		1 hour	40	2.4
2.8 lbs./cu.ft.		10 days	25	0.8
Improved poly-	12" x 12" x 4"	Immediate	23	8.0
ester with		1 hour	18	6.0
special catalyst		10 days	4	3.0
2.8 lbs./cu.ft.				

The principal structural feature common to the catalysts in Groups B and C is the position of the oxygen atom which is beta with respect to the nitrogen atom: -N-C-C-O-. Why this structural peculiarity produces these specific effects is still not known. As foaming catalysts, these amines are slower and produce a lower exotherm than is encountered with the usual catalysts. It is possible that these catalysts promote the chain extension of the polyester in preference to crosslinking and CO_2 evolution processes. It has also been established that these catalysts produce foams with a much higher degree of closed cell structure than the usual catalyst systems—both factors in the improvement of rebound properties.

Several amines from Groups A and C which had about equivalent foaming activity were added to 65/35 TDI stored in brown, sealed bottles at room temperature over a one month period. The following changes in NCO content and appearance were noted at the end of this time.

TABLE VI. Changes NCO Content

Amine*	Original % NCO	% NCO After 1 Month	Appearance
N-Hydroxyethyl-morpholine (Group C)	47.6	47.4	Very small amt. of crystals on sides of bottle
N-Methylmor-pholine (Group C)	47.85	47.8	Very small amt. of crystals on sides of bottle
Tri-n-butyl (Group A)	47.8	40.6	Large amt. of crystals on sides and bottom of bottle
Tri-n-propyl (Group A)	47.7	43.1	Large amt. of crystals on sides and bottom of bottle

* 0.3 gram per 25 cc. TDI.

Melting points on the crystals isolated from the above mixtures indicated TDI dimer was mostly present along with small amounts of other TDI polymers.

If the amines of Group A promote a high degree of dimer formation during the course of foaming and subsequent curing, the nature of the foam can conceivably be different from that produced by the amines in Groups B and C.

Earlier, mention was made that this particular amine system has been proven best with the use of neutral nonionic and anionic emulsifiers. Limited work with emulsifiers having acid numbers ranging from 10 to 160 indicated that the tendency of these amines to impart good resiliency in foams is decreased when such emulsifiers are used. Further work on the nature of the interference produced with these acidic emulsifiers was not pursued.

The work reported here has shown that the nature of the tertiary amine catalysts plays an important role in determining the final properties of the polyester foam. While their exact role is not fully understood, significant improvements in the cushioning properties of polyester urethane foam have been made by the proper choice and use of these catalysts.

Literature References

(1) Winkler, J., *SPE Journal*, Vol. 12, No. 11, 23 (1956).

Rigid urethane foams with the highest number of small closed cells make possible an efficient low temperature insulation. This article describes the various physical and chemical factors which govern the preparation of such urethane foams.

Designing Rigid Urethane Foams For Low Moisture Permeability

C. Minor Barringer

E. I. du Pont de Nemours & Company, Inc.

Urethane foams are at the threshold of wide acceptance as commercial insulation materials. They combine in one material excellent insulation efficiency good structural strength, and good inherent adhesion to many types of surfaces. These materials allow lighter and simpler design when foamed in place and can lead to less costly manufacturing processes for a wide variety of composite structures. This article describes the variables affecting permeability.

Low moisture vapor permeability of an insulating material is particularly important in low temperature applications. Insulation that is permeable permits absorption of moisture vapor and ice formation against the cold wall. This causes a loss in over-all insulating efficiency since water and ice are relatively good heat conductors. The accumulation of ice can also cause structural damage to the insulation. Applications where temperature cycling takes place are less critical with respect to moisture permeability of the insulation since the interior wall is periodically warmed to ambient temeprature, permitting the insulation to breathe and equalize its moisture content with the surrounding air.

Penetration of moisture into low temperature insulation may be prevented in either of two ways. The first is by selection of an insulating material which is inherently resistant to moisture. The second is by the use of an impermeable moisture barrier over the insulation. Moisture permeable urethane foam insulation, properly sealed, is performing very well in service involving cold wall temperatures as low as −70°F. for extended periods. The use of a vapor barrier requires an additional operation after the foam is formed. This step is not practicable in many cases. Closed cell urethane foams based on hydrophobic polymers have low moisture permeability and do not require a moisture barrier. The preparation of such foams together with the variables influencing the nature of the polymer and of the physical characteristics of the foam as related to moisture permeability is described below.

Theoretical Considerations

The permeation of organic polymer films by gases varies with the chemical nature of the polymer and the vapor involved. The mechanism of permeability has been described[1] as the combination of two physical processes: the solution of the gas in the film, and diffusion of the gas molecules through the film. This relationship is expressed in Fick's Law, as follows:

$$Q = \frac{DS\,\Delta p}{L} = \frac{P\,\Delta p}{L}$$

Where:

Q = amount of gas passing through film in time (t)
D = diffusion constant of the gas
S = solubility coefficient of the gas
Δp = pressure differential on two sides of film
L = thickness of film
P = permeability constant = DS

It is evident from this equation that a change in permeability can result from changes in either the solubility of the gas in the polymer or the rate of diffusion of the gas through the polymer. Solubility depends on gas-polymer interactions for any given system and will vary widely with the chemistry of the polymer and gas being measured. Water vapor may be considered as a polar gas in perme-

ability studies. Urethane polymers contain highly polar urea and urethane linkages and show relatively high solubility for gases such as CO_2 and water vapor. Diffusion is controlled by the spatial configuration of the polymer and the attractive forces between its chains. For example, a linear polymer will allow a gas to diffuse more readily than a highly cross-linked structure.

Permeability to moisture or other gases is influenced by the gross physical structure, as well as by the chemical factors discussed above. Foamed polymers having a structure which is open or one composed of particles sintered together present a poorer barrier to a gas than those having continuous structures of closed cells.

Close examination of a urethane foam reveals cells which are irregular polyhedra. The presence of holes in two or three faces will permit free passage of gas between adjoining cells, so that the cell structure is open. Such a foam presents a labyrinthine, but essentially continuous, passage to a penetrating gas. The finer the cell structure of such a foam, the more resistance will be offered to gas passage.

In closed cell foams, the faces of adjoining polyhedra are intact. Thus, the moisture permeability is related to the chemical structure of the foam and is less dependent on physical variables such as cell size. However, a fine cell structure imposes a greater number of individual polymer films through which the vapor must pass.

Experimental

Two general techniques were used to prepare the rigid urethane foams used in this study. These were: 1. the method in which resin or polyol is reacted with toluene diisocyanate to produce an isocyanate terminated liquid product known as "pre-polymer." Water and catalyst are added to the prepolymer to prepare a foam; 2. a semi-prepolymer is prepared by reacting part of the resin component with a large excess of toluene diisocyanate to produce a liquid product of low viscosity and high free isocyanate content. The semi-prepolymer is reacted with additional polyester resin, together with water and catalyst, at the time of foaming.

The first technique is used with resin systems containing a relatively low concentration of reactive hydroxyl groups; e.g., hydroxyl numbers of 250 or less. The second technique is applicable to all resins but is particularly suited to systems of high hydroxyl content (hydroxyl numbers of 350 or higher).

Foams were prepared either by hand mixing the necessary ingredients or by pumping the components through metering equipment and mixing in a continuous mechanical mixer of simple design, powered by a variable speed air motor. The foams were molded in ½-gallon waxed ice cream containers.

The physical properties of foams which were measured included density, compressive strength, percentage of closed cells, and moisture permeability of both the foams and cast films. The percentage of closed cells was measured by the air displacement method described by Remington and Pariser.[3] Moisture vapor permeability of foams was measured by a modified dry cup method similar to ASTM Procedure E96-53T. 2″ x 2″ x 1″ slabs of foam were cemented to the tops of small screw top jars containing alumina-gel desiccant and the assembly placed in an oven held at 100°F. and 100 per cent relative humidity. Weight gain of the foam and desiccant were determined at regular intervals. The moisture permeability in perms/inch was calculated from the observed rate of moisture transmission of the foam sample. Tests were carried out over a four-week period to ensure an equilibrium rate of moisture transmission.

Chemical Factors

Urethane foams may be prepared by reacting aromatic diisocyanates with almost any compound containing two or more aliphatic hydroxyl groups. Thus, great variation in the chemical nature of the polymer is possible through the selection of the type of polyhydroxyl compound to be used. The system is not completely variable, however, because of the chemical reactions involved in generating the carbon dioxide gas which expands the foam. Roughly equal molar amounts of water are required to produce urethane foams of equal density. In practice, it has been found that a foam of 2 lb./ft.³ density contains approximately equal weights of hydroxyl-containing and isocyanate components, regardless of how it is prepared. Thus, the number of highly polar urethane and urea groups is relatively constant, and control of the hydrophobic or hydrophilic nature of a urethane foam polymer is accomplished by varying the chemical nature of the resin portion of the foam.

Table I shows the influence of polymer structure on moisture vapor permeability of urethane foams having equivalent closed cell content, cell size, and density.

TABLE I. Effect of Resin Type on Moisture Permeability of Rigid Urethane Foams

(All at approximately 2 lb./ft.³ density)

Resin System	100°F Permeability Perm-inches
Mixed Polyethers	6.8
Polyester based on short chain acids	5.6
Polyester based on long chain acids	3.4
Polyol-Urethane (low M.W. polyol plus TDI)	2.8

These foams were prepared from resins of approximately equal hydroxyl content but different molecular weight and/or chemical structure. The foam based on low molecular weight polyether glycols has the highest permeability. The foam prepared from a polyester resin based on short chain dibasic acids and polyols shows slightly lower permeability. The polyester based on long chain fatty acids has still lower permeability. These three foams thus illustrate the effect of using an increasingly hydrophobic resin in the polymer. The fourth example in Table I shows the importance of molecular attraction between the polymer molecules. This foam was prepared from the reaction product of toluene diisocyanate and a mixture of low molecular weight diols and triols having the same degree of functionality as the other foams of this series. The resulting polymer has a very close spacing of urethane groups and forms a foam of low moisture permeability. It is believed[4] that a high degree of hydrogen bonding contributes to the low permeability in this case.

The diffusion of gas through the foam polymer can be reduced by making it more difficult for the gas molecules to pass through the polymer network. In urethane foams, the polar interactions between polymer chains may be increased by increasing hydrogen bonding as was done in Example 4 of Table I, or by increasing the degree of cross-linking by primary chemical bonds. Both of these objectives are accomplished by using resins having a large number of reactive hydroxyl groups. These can be reacted with diisocyanates to give a high concentration of highly polar polyurethane cross-links.

The influence of the degree of cross-linking on the moisture permeability of urethane polymer films is shown in Table II.

TABLE II. Effect of Cross-Link Density on Moisture Permeability of Polymer Films (4)

Film	Mc*	S (cc/gm-atm)	R (cm²sec⁻¹atm⁻¹)
Polyether-urethane	20,000	560	235×10^{-6}
Castor oil-urethane	2,300	390	5.7 "
Commercial rigid foam polyester-urethane	400	-	1.0 "
Polystyrene	not cross-linked	-	15.6 "

* Average molecular weight between cross-links.

A moderately cross-linked castor oil based urethane polymer ($\overline{M}c$ about 2300) has a much lower moisture permeability than a very lightly cross-linked polyether based urethane polymer ($\overline{M}c$ over 20,000) or than a linear, hydrophobic polymer such as polystyrene, with essentially no cross-linking[3]. The highly cross-linked commercial polyester gives still lower permeability. Two of the urethane films shown in Table II dissolve approximately equal amounts of water. The diffusivity, therefore, is the governing factor in this case. This observation is supported by studies on rubber films[6] which show that gas permeability decreases with increasing degree of vulcanization, through solubility of the gas in the polymer remains unchanged.

Foams can be prepared by evaporating volatile liquids of relatively high molecular weight within the reacting urethane mass. These foams are of commercial interest because of their extremely low thermal conductivities. Since expansion is caused by the evaporating liquid, no water need be added to generate carbon dioxide. The vapor used for expansion must have low solubility in the urethane polymer. Trichlorofluoromethane ("Freon" 11) is an effective material for this purpose. The moisture vapor permeability of foams prepared by this means is considerable lower than that of foams prepared in the conventional way from the same resin, as shown in Table III.

TABLE III. Reduction in Moisture Permeability by Changing Gas in Foam Cells

(Polyester-based Foam, 2.5 lbs./ft.³ density)

Gas in Cells	100°F Permeability Perm-inches
Air	5.6
"Freon" 11 and Air (60%-40% by volume)	4.3
"Freon" 11	2.8

Partial replacement of carbon dioxide by "Freon" 11 vapors was found to reduce moisture permeability significantly. These effects stem from two causes. One is saturation of the polymer by the "Freon" vapor in the cells, which decreases its compatibility with water. Furthermore, the cross-link density of the polymer is increased as a result of the use of a polyfunctional resin in the foam formulation in lieu of water. The calculated $\overline{M}c$ of the urethane polymer is reduced from 550 to 375 in a typical "Freon" 11 expanded system.

Plasticizers and fillers, in general, adversely affect the moisture permeability of rigid foams. Table IV shows the moisture vapor permeability of a polyester based foam containing several types of fillers.

TABLE IV. Effect of Fillers on Moisture Permeability of Rigid Polyester-Urethane Foam

Filler (6 parts per 100 by wt.)	100°F. Perm-inches
None	5.5
Hi-Sil 234	5.5
Graphite	5.3
Dixie Clay	6.5
SAF Black	7.0
Aluminum Powder	8.1
Celite (Diatomaceous $CaCO_3$)	8.3
Santocel CS (ppt'd SiO_2 gel)	9.0

The effect ranges from negligible to very adverse, depending on the shape and surface area of the filler particles. Low-surface or platelet shaped fillers such as Hi-Sil or graphite do not increase foam permeability. Inorganic fillers which are hydrophilic, such as clays and metal powder, increase permeability. Certain additives, having high surface area, such as Santocel CS, apparently cause imperfections in the cell walls and result in an open cell structure.

Plasticizers act as diluents, separating the polymer chains and allowing moisture to pass through more readily. The data in Table V show the effect of several plasticizers on moisture vapor permeability. Coal tar, which has only a minor effect, is reactive with isocyanates and hence does not act as a true plasticizer. Trioctyl phosphate has a surfactant effect and results in an open-celled foam.

TABLE V. Effect of Plasticizers on Moisture Permeability of Rigid Polyester-Urethane Foam

Plasticizer (6 pts. per 100 by wt.)	100°F. Perm-inches
None	5.5
Coal Tar	6.1
Chlorinated Terphenyl	9.5
Polypropylene Adipate	10.3
Trioctyl Phosphate	21

The relationship between plasticizer concentration, degree of cross-linking, and gas permeability has been demonstrated in elastomeric films[7].

Physical Factors

The permeation of a gas through a polymer is inversely proportional to film thickness. Hence, the physical structure of a urethane foam will influence its effectiveness as a moisture barrier, depending on whether the cells are open or closed, the size of the cells, and the bulk density of the foam itself.

Closed cell structure is the most important physical factor contributing to foam impermeability. The number of closed cells governs the total thickness of polymers through which moisture must pass. *Figure 1* shows this relationship of closed cell content in a typical foam. Foam containing only 10% closed cells is four times more permeable to moisture than one containing 100% closed cells.

Moisture permeability of a foam is related to the average cell diameter. Small cells are also beneficial to low thermal conductivity since convection is minimized. *Figure 2* shows the effect of average cell diameter on the moisture vapor transmission of an open celled, castor oil foam. Reducing the average cell size from 2 mm. to 0.5 mm. reduces permeability by 60-70%.

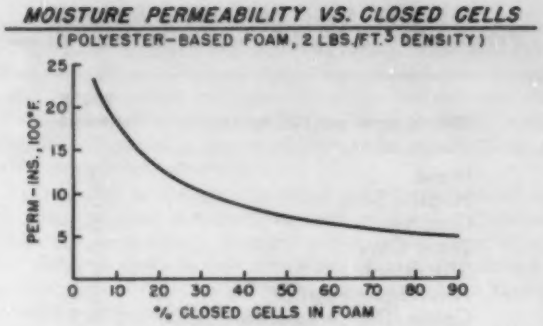

Figure 1

The moisture vapor permeability of the foams decreases with increasing density. *Figure 3* shows this relationship in two polyester based, urethane foams. Dense foams contain small, closed cells with thick walls. High foam density also leads to higher cross-link density since water is replaced with polyfunctional resin. These factors all decrease moisture vapor permeability.

Formulation and Mixing

Fine cell structure and a high percentage of closed cells are obtained by the use of the proper resin and surfactant, combined with optimum mixing conditions. A resin of high hydroxyl content is desirable since it has a large number of cross-linking sites per unit weight. Such a resin yields a polymer which gels rapidly, forming cells of sufficient strength to retain the carbon dioxide gas as it is generated. Resins having a hydroxyl number of at least 350, and preferably 400-475, are necessary for maximum closed cell content. This corresponds to a range of equivalent weight per OH group of 118 to 160. Resins of higher hydroxyl number lead to excessively brittle foams.

Knowledge of the average molecular weight between cross-links is necessary in designing rigid urethane foam systems. This can be estimated from a knowledge of the structure of the reactant molecules used. The average molecular weight between cross-links is abbreviated $\overline{M}c$ and is calculated as follows:

$$\overline{M}c = \frac{\text{Total weight of ingredients taken}}{\text{Mols of cross-links in this weight}}$$

It will be shown later that $\overline{M}c$ can be used as a guide to controlling the physical, as well as the chemical, characteristics of the foam. The calculation is based on the premise that only molecules containing three or more functional groups (—OH or —NCO) can provide cross-linking. One cross-link occurs for each functional group in excess of the two which are required for chain extension.

This calculation makes no allowance for the spatial configuration of the polymer molecule. It does, however, serve as a useful guide for choosing foam ingredients of a proper degree of functionality to obtain the desired product. An $\overline{M}c$ in the foam polymer of 600 or less is required for closed cell foams. Figure 2 and Table VI show the effect of resin functionality on closed-cell content and moisture permeability.

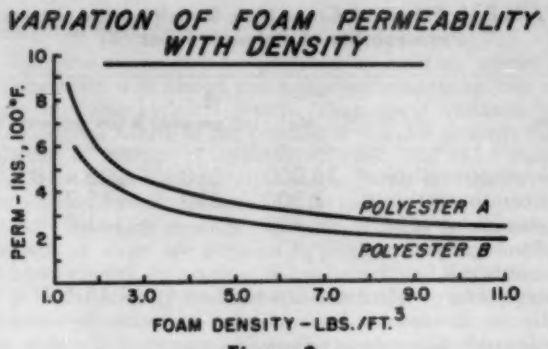

Figure 3

TABLE VI. Relationship of Mc of Rigid Urethane Foams to Closed Cell and Moisture Permeability

(Hydrophobic Resin System)

$\overline{M}c$	% Closed Cells	100°F. H_2O Permeability Perm-inches
2300	5	18-22
1500	15	14-18
600	65	7-8
500	85	5-6
350	90	3-4

Rigid foams of high closed cell content are prepared most successfully by the "semi-prepolymer" technique described in the Experimental Section. When "prepolymers" are prepared from resins of high hydroxyl content, their viscosity is too high for practical processing. *Figure 4*

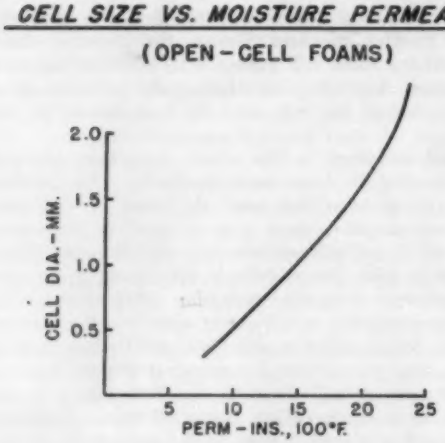

Figure 2

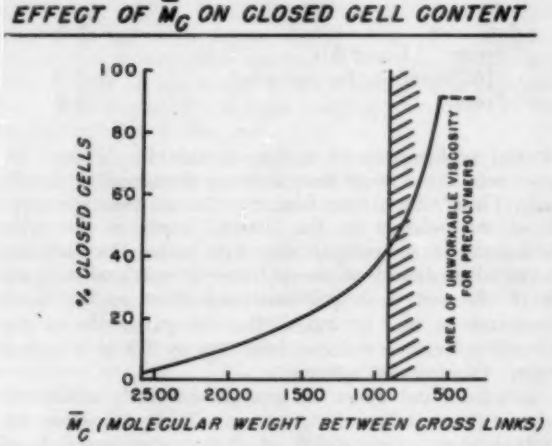

Figure 4

shows that the viscosity obtained at an $\overline{Mc}$ of about 1000 is too high for practical use. This degree of cross-linking is too low to give closed cell foams.

The surfactant used to assist the blending of the foam ingredients can profoundly influence the foam structure. Table VII shows the effect on foam cell structure obtained from various surfactants.

TABLE VII. Effect of Surfactant on Cell Structure of A Rigid Polyester-based Foam

Surfactant Type	Conc. (wt., %)	% Closed Cells
None	-	50-55
Sorbitan-Polyoxyethylene fatty ester	0.6	collapse
Sulfonated polyoxyethylene veg. oil	0.6	collapse
Methyl Silicone Oil	0.3	collapse to 5%
Polyoxypropylene-polyoxyethylene block copolymers	0.3	5-20
Polyoxyethylene-alkyl phenols	0.6	45-55
Alkylsilane-polyoxyalkylene copolymers	0.3	60-90

Not enough is known at present to generalize concerning the relationships between surfactant chemistry and its effects on foam properties. Many non-ionic surfactants aid dispersion of water and catalyst in resin without greatly influencing cell structure. Other types of surfactant promote formation of open-cell foams or lead to collapse. The alkylsilane-polyoxyalkylene copolymers are important aids when preparing foams of low moisture permeability because they produce extremely fine, uniform foams of high closed cell content. The use of these compounds gives a very stable liquid froth, which holds the gas in the cells until gelation can occur. Methyl silicone oils promote coalescing of bubbles and cause foam collapse.

Catalyst type and concentration are relatively unimportant in urethane polymer systems having sufficient cross-linking to produce closed-cell structures. Most tertiary amine catalysts produce a rapid rate of gelation when used in low concentrations in such systems. Foams based on resins of lower functionality may require the use of a higher concentration of catalyst, or a more basic catalyst, to increase the percentage of closed cells by increasing the rate of gelation of the polymer. For example, the closed cell content of a castor oil based foam was increased from 10% to 50% by changing the catalyst from partially neutralized diethylaminoethanol to diethylaminoethanol. Resins containing secondary hydroxyl groups, or isocyanates which are less reactive than toluene diisocyanate give lower rates of urethane formation which may be compensated for by more active catalysts. Much higher concentrations than the usual 0.2-0.5% of strong tertiary amines may be necessary. Co-catalysts that specifically promote urethane formation, such as ferric chelates, are also helpful in such cases.

Mixing is Important

The effects of proper formulation may be obscured by improper mixing of the foam. Both undermixing and overmixing of the ingredients can lead to inferior foams of low closed cell content and hence greater moisture permeability. Insufficient mixing leads to poor distribution of the ingredients, causing high local concentrations of partially reacted resin or isocyanate components. Excessive mixing can cause mechanical shear of the polymer after it has begun to polymerize. The influence of mixing speed on cell diameter and per cent closed cells is shown in *Figure 5*. An increase in degree of mixing past the optimum leads to a decrease in the percentage of closed cells and the coarse cell structure. Extreme overmixing leads to collapse of the foam because of mechanical breakdown of the reacted polymer before it is in place. Mixing should be just sufficient to blend the resin and isocyanate components to a homogeneous fluid. The correct mixing conditions must be determined experimentally for each foam system.

EFFECT OF MIXING SPEED ON FOAM QUALITY
(AT CONSTANT THROUGHPUT)

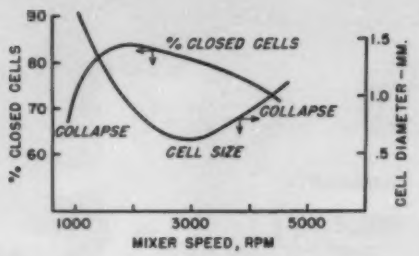

Figure 5

Summary

Rigid urethane foams having low permeability to moisture are prepared by control of resin design, foam formulation, and mixing. The most important considerations are those which result in the highest possible number of small closed cells in the foam. Knowledge of these principles is permitting urethane foams to find wider application as low temperature insulation. The economies made possible in design and construction permits them to replace conventional insulating material in an increasing number of uses.

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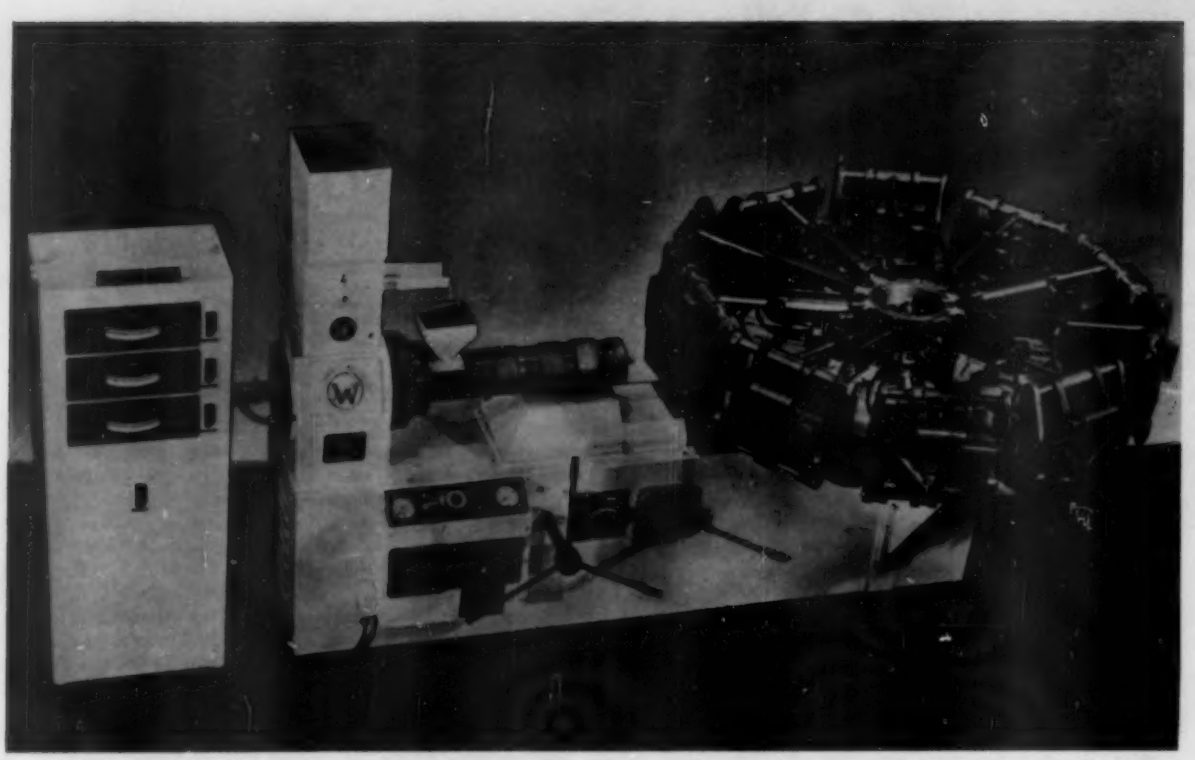

Low Pressure Injection Molding

Gordon Cooper

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The Foster Wucher machine pictured is a high speed 4" extruder fitted with an electro-magnet clutch to disengage the drive in between filling a series of 10 molds which are fitted on a rotary table in front of the extruder nozzle. This machine has many advantages when compared against the old type machines and just a few are as follows:

The plasticizing is homogeneous due to the mixing action of the extruder screw. This mixing action provides considerable internal movement within the material permitting the use of master batch techniques. The plasticating volume is unlimited within the confines of a 4" extruder running at high speed. Another very important feature is that the rotation of the screw builds up frictional heat which allows the cylinder band heaters to be switched off once the machine has started to operate which is, of course, true adiabatic extrusion. It is quite obvious that so much heat is put into the material by the screw which is stationary in between filling the molds. The cylinder wall temperature can be quite low, allowing the material to remain static in the cylinder for long periods without fear of decomposition. With this type of machine the pressure built up for injection is supplied by rotation of the screw and not by the action of a ram forcing the material forward.

The 10 heavy duty mold carriers or mold boxes are installed on the rotary table and indexed to the nozzle for charging. A very important feature of the mold-carriers or mold boxes is that the molds contained in the boxes are not subject to severe strain and can be manufactured from low cost alloys. Still another feature pertains to molding of various items which require a core or insert and the practical method of inserting and removal of the finished product from the mold cavity has many advantages.

Low pressure injection or "extrusion molding" offers advantages in producing a very uniform melt. The process has interesting production possibilities, since in theory, there is no limit to the shot capacity which can be handled.

During the past two years the extrusion field of the plastic industry has become more aware of the fact that the heating of thermoplastic materials by internal friction is the most effective method of producing a uniform melt. This factor is now so important that extruders exist in which all the heat used is furnished by frictional working (adiabatic extrusion). Other extruders use a small proportion of conducted heat, but even with these the correct working of the machine is dependent on the shear action of the screw and the resultant frictional heat. The present trend in extrusion is to use less conductive heat resulting in improved quality of products manufactured, as well as increased production.

With flexible P.V.C., polystyrene, and similar material maximum pressures of 3400 P.S.I. can be obtained. With more viscous materials such as rigid P.V.C., pressures greater than 6000 P.S.I. can be obtained in the end of the cylinder. Although these pressures may appear low in comparison with standard injection machines, it is to be noted that molding pressures on such machines taken in the mold cavities are often only 6000 P.S.I. and occasionally certain materials may build up to 10000 P.S.I. thus showing considerable pressure loss in pushing the material forward. Still another very important feature related to screw plasticating is the thixotropic effect whereby high rates of shear the apparent viscosity of material is lowered. Such effects in general do not occur in the shear rates encountered with standard machines. This assists in mold filling. As a result of the low injection pressure with certain materials the valve nozzle can be released from the mold almost instantly after the injection has been completed. This applies particularly to thick section moldings which, on standard machines, would require long "follow up" times, thereby making it possible to utilize a rotating table allowing the moldings to cool as the table rotates without losing the efficiency of the plasticating section.

Materials having high shrinkage, have proved difficult to mold by the methods discussed previously, but recent experimental work indicates that such materials can be molded by running the screw beyond the filling time which is, in effect, a follow up pressure. In general, it has been found that each mold has a definite filling pressure. If this pressure is built up at the nozzle excellent results are obtained.

In order to avoid allowing the pressure to build up to a greater value than the filling pressure, the following procedure is followed:

Most extruders operate with a hopper fitted direct to the cylinder and the screw is full of material right up to the hopper. Material is fed into the cylinder by a vibrator dispenser, so that it is possible to control the length of the cylinder filled with material. This length in turn determines the ultimate pressure which can be built up at the end of the cylinder so that by having only sufficient material in the screw flights to develop the mold filling pressure at that point this new technique can be applied. For the best results using this technique, it is preferable to use weigh feeding instead of using a vibrator or volume dispenser.

HOW THIN WALL SECTIONS CAN BE MOLDED BY EXTRUSION MOLDING

A new plasticizing head with a modified screw plasticizing is used. As the material reaches the front of the screw, it progressively fills a plasticizing chamber which increases in volume as more material enters, by the cylinder sliding out along the screw. A limit switch is arranged to stop the screw when the necessary volume of material for filling the mold has entered the chamber. A ram then pushes the plasticizing head forward and the valve nozzle at the end of the cylinder is opened, allowing the material to flow into the mold. When back pressure builds up the non-return valve at the end of the screw closes and the screw starts to move forward in the cylinder forcing material into the mold. When the screw has moved forward as far as necessary, follow up pressure is applied. If this is not necessary, the unit can be retracted as a whole at this stage as the cycle repeats itself. At the present time this head is available as a 16-ounce unit but larger units will be available in the near future.

Plastics in the Auto Industry

Plastics are now being accepted on their own merits and not as a substitute for metals, rubber and other materials.

Plastic Tubing for Automotive Applications

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Rubber, metal and plastics comprise the major engineering materials used in automotive tubing. Plastics offers superior aging characteristics, better chemical resistance and greater physical strength over rubber. In the area where metals are commonly used, plastics offer better corrosion resistance, greater flexibility, which results in ease of assembly, and generally lower costs.

Ability of plastic materials to resist prolonged exposure to temperatures common to the automobile is of prime importance. Under hood temperatures at selected spots may rise as high as 300°F. The use of thermoplastic materials at these temperatures has been unthinkable until recent advances in polymer chemistry successfully advanced the temperature barrier from its original peak of 200°F. to the present 275°F. and, under conditions of low stress, to 300°F. Of course certain plastic materials are presently operating at 450°F. to 500°F.

Impact resistance with its implication of resistance to breakage under violent manipulation or when struck by rocks or wrenches is likewise important to the automotive user. It is no longer true that zero weather makes all plastic parts fragile. In fact, the problem in determining embrittlement at low temperature is now a difficult exercise in low temperature engineering. Function at −60°F. is now an easy task for several commonly accepted plastic materials.

The plastics family excels in its reaction to chemicals—or rather lack of reaction. Acid or base, solvent or absorbent—all of these reactions have dwindled to insignificance under the recent advances in polymer chemistry.

An application which shows good competitive advantage from both cost and performance standpoints is the fuel line from the gasoline pump to the carburetor. The wide variety of customer options on both carburetors and engines for a single automobile model has created a problem in this area. Four different carburetors have been used on one engine. This resulted in four separate fuel lines being required, each bent to a different complicated shape. The advantages of a single piece of flexible tubing replacing four different parts are obvious. The costs of making the complicated bends on four different parts and the resultant higher shipping and inventory costs are serious disadvantages for metals. The advantages are even greater on certain truck and industrial engine models. The physical requirements on this application are high. So far, a material in the competitive price range which will have sufficient tensile at the higher temperatures and a degree of flexibility which will not require prebending has not yet become available. It seems certain, however, that developments by the materials suppliers should soon provide a satisfactory material.

The fuel line running from the gasoline tank to the fuel pump is an application of much recent interest. The complexity of the new frame and underbody designs have made the assembly of a metal tube very difficult and in some cases impossible. This has resulted in some rather expensive rubber constructions being used which, from some reports, have not been entirely satisfactory. Several current materials have been tested and have been found to be satisfactory insofar as carrying the fuel is concerned. The de-

PLASTICS ENGINEERS' IDEA BOX

Some applications on which plastics are or should be considered but on which further engineering study needs to be made:

Gasoline tank air vent tubing
Radiator and heater hoses
Power steering and hydraulic brake hoses
Protector for wire harnesses
Conduit for the wires that go through either the frame or body at certain points
Air suspension systems
Vacuum tubing
Pneumatic controls
Drain tubes
Automatic transmission cooling systems
Oil level tubes
Door actuator silencers
Electric cable spaghetti

gree of flexibility obtainable in higher strength materials, however, has not met the ease of assembly requirements.

The radiator overflow tube is another application which has a real potential for plastic tubing. Several available materials are satisfactory from the standpoint of temperature and chemical reactions. A cooperative approach to the problem by processor and user should result in satisfactory applications from both an assembly and cost standpoint.

The windshield washer hose has been the subject of considerable discussion during the past year. During the current model year, one of the companies used plastic tubing in this application for about three months with rather unsatisfactory results. The problems encountered were mostly in the area of the joint between the tube and the fitting. The experience gained in this application strongly suggests that a satisfactory fitting can be designed which will permit using the plastic tubing to advantage. Its longer life, chemical and corrosion resistance and freedom from contamination as compared with rubber requires that it be made available to the public.

A considerable amount of interest has recently been shown in the use of plastic tubing on push-pull controls. Linear polyethylene tubing replacing the metal sheathing has shown considerably lower friction and longer life. Costs are also lower. Another advantage is its greater resistance to kinking. When an all metal assembly is accidently kinked it results in a very unsatisfactory operation because of the residual bend. Plastics construction overcomes this problem. There is still a problem of a satisfactory end clamp and the control of the differences in thermal expansion on the longer lengths, neither of which problems appear to be serious.

Emergency brake cables are another application of this type. It appears, however, that a plastic outer sheathing alone will not be entirely satisfactory but that a reinforcement of some type will be needed over the plastic tubing. There is no question but that improved operating efficiency can be achieved by the use of a low friction plastics liner. This is an application where a possible increase in cost should be evaluated against the improved efficiency.

Speedometer cables and power actuators of the same construction are very definite possibilities. A nylon liner in a flexible steel sheath on a power actuator cable has been successfully used to reduce noise and improve efficiency. This, however, resulted in higher costs. It is possible that a plastic tube could replace the flexible steel sheath with a resultant lower cost. One of the main problems has been the difference between the thermal coefficient of expansion of the housing and the core. A detailed study of this problem with a possible change in design in the end couplings will overcome the problem. This is a very good practical application which will result in better performance and lower cost.

■

Growth of Plastics in European Cars

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Polyethylene (regular)—this material is used to hold the windshield washing fluid on some Citroen models, in the SAAB, Ford Taunus, Volkswagen and other European cars. Fiat uses polyethylene as a water shield for inner door panels. Ford Taunus uses polyethylene shock absorber and front wheel suspension covers. Renault uses more than five polyethylene parts. Opel uses four. Fiat also uses linear polyethylene as a spring leaf liner.

Polypropylene—used to make sun visors for the 500 and 600 Fiat. It is planned for the glove compartment of the Fiat 1100. Fiat is working on a polypropylene fan.

Polyvinyl Butyral—Use of polyvinyl butyral safety glass is more widespread in this country than in Europe. However, new laws, e.g., in Italy, will expand the use of this product in Europe. Also, the increase in traffic density in Europe and the absence of speed regulations outside the cities should tend to make people think of the safety of their motor car glazing. Some solid plastic glazing has been used by Citroen (rear window) and by Fiat.

Reinforced Plastics

Interest is strong and applications considerable in France, Italy, England, Sweden, Germany and Holland. Reinforced plastic tooling is used in Europe, e.g., by Jensen Motors, Ltd., but a comparison of the extent thereof in Europe vs. the U.S. is not known. Complete glass-reinforced bodies are used in England by Peerless and by Typhoon Cars, Ltd., by the Midland Red Bus Company and by others. A glass-reinforced top is used in some

Nylon dashboard moldings used by Citroen

Plastic rear window in Fiat, welded to PVC top

models of Citroen. A polyester glass dashboard has been fitted to an Alvis car. Polyester "elements of coachwork" are used by Renault.

There is keen interest in Europe in a new methyl methacrylate sirup for reinforcing, though it is not yet available in commercial quantities. It provides in reinforced products the outstanding weatherability for which methyl methacrylate has long been noted.

Polyvinyl Chloride

PVC leather cloth has wide application for upholstering, headlining, coated mats, PVC covered felt, piping, trim, panel covers, etc. It sometimes takes the form of plasticized PVC laminated to polyurethane foam. Other PVC uses: door-casing covers and steering column shrouds (Rover), cable covering (Volkswagen, Fiat, Standard Motor Co., Ltd., Austin), sunshades (Volkswagen and Standard Motor Car, Ltd.), armrests (Volkswagen, Ford Taunus, Fiat), "assistance" strap (Ford Taunus).

Nylons—Nylon pins, brushes, and buffers for lock and striker mechanisms or other door-lock parts are used by Morris Motors, Ltd., Saab, the Standard Motor Car Limited, Ford Taunus and others. Renault uses a nylon door handle, heater shutter, air filter, oil filter, ball-bearing holders and accelerator links.

Nylon is used by Volkswagen as the carburetor float, lock parts, as a slide piece for the sliding roof, as rolls for the sliding roof, as part of the sliding roof closure, etc. Opel uses nylon door check rollers.

Nylon speedometer drive wheels or gears are used by Saab, Standard Motor Car, Ltd., and probably others. Renault uses three nylon tachometer parts. Nylon gears for the windshield wiper motor are used by the Standard Motor Car Co., Ltd., and probably by others.

Cellulosics—Acetobutyrate is used for steering wheels by Ford Taunus and probably others. Renault uses it in a visor, a radio grille, in numerous buttons, knobs, handles, etc. Opel uses acetobutyrate for various control buttons.

Cellulose acetate knobs are used by Peugeot, but acetobutyrate parts are used as well. Standard Motor Company, Ltd. also uses cellulose acetate door handle knobs and escutcheons. Fiat has replaced cellulose acetate parts with acetobutyrate ones. The list is not inclusive.

Acrylics—Acrylic (polymethyl methacrylate) tail light and signal light lenses are the rule in European cars. It is also used in the dome lamp of Ford Taunus and of Volkswagen.

Acrylic ornaments and escutcheons are used widely in European cars as they are in American ones.

An acrylic pane is used for the speedometer by Citroen, and an acrylic mirror by Renault.

Volkswagen uses acrylic devices for illumination of numbers, etc.

Fiat uses acrylic anti-draft door panels.

We found some acrylic copolymer motor car parts in the U.S.S.R.

Thermosetting Resins

Phenolics are used by Fiat primarily for electrical parts. For such parts it is probably used by others as well.

Melamine is used as bulb holders by Fiat and for various handles, knobs, and buttons by Volkswagen, Renault, and perhaps by others.

Thermosets are used in other mechanical parts by Volkswagen, Opel Renault, and others. Thus, Renault uses a phenolic water pump pulley.

They are used in decorative and functional parts by Rover, e.g., instrument housings, steering column shrouds, etc. The Standard Motor Co., Ltd. use phenolic ashtrays, knobs, "cubby box" parts, radio panel and controls, heater panel and controls, etc. Phenolic ashtrays are used by Opel. Urea-formaldehyde ashtrays are used by the Standard Motor Co., Ltd.

Polystyrene—Polystyrene is used by Volkswagen as signal arrows. It is used by the Standard Motor Car Co., Ltd. and by Opel as a door-arm rest base, by Saab and by Opel in the sunvisor, by Ford Taunus as battery plugs. Opel uses a polystyrene steering column cover and instrument lighting housing. Peugeot is planning to extend the use of shock-resistant styrene-based polymers for two grilles. Renault uses this material for various heater duct parts. Polystyrene interpolymers are used by Morris Motors, Ltd. in trim finishes, as roof linings, and in decorative protection moldings. Citroen uses this material for part of the dashboard. Saab uses styrene acrylonitrile interpolymer as a draught excluder for the door. Fiat uses heat-resistant and shock-resistant styrene interpolymers in interior parts exposed to direct sun heat. These include a dashboard under development. Styrene-butadiene-acrylonitrile is used by Renault for the sunshade and for interior door handles.

Polyurethane—Polyurethane foams are used by Morris Motors Ltd. for resilient seat overlays. This firm also uses isocyanate-based polymers, applied as liquid in making seals in certain more inaccessible areas. Ford Taunus uses a polyurethane transmission gear shift lever bushing and two other bushings made from this material.

Fiat uses polyurethane as bushings and in foam form as padding in inner door panels. Polyurethane foams based on polyethers are liked by Fiat for cushioning because of better resilience. Renault uses polyurethane cushioning and "deadening joints". Volkswagen uses polyurethane foam in armrests and in sound control. Rover uses polyurethane sheet to cover certain interior parts. Opel uses a polyurethane brake stop. A bushing, a bearing and a ball socket of this material are also used by Opel. ■

The Automotive Field and Blow Molding

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The automotive field represents a substantial volume market for blow molded items. Stability of low pressure polyethylene towards oil makes possible two applications currently in production in Europe: First is a brake fluid reservoir unit that has already been installed in the Mercedes Benz and the Rolls Royce; second, an oil can used for lubricating various parts of an automobile.

Windshield washer tanks are also currently produced complete with multiple openings or lugs for installation on the fire wall of the car.

Blow molded gasoline cans are used extensively in France. It is necessary to consider, however, the fact that permeation of gasoline vapor through a thin wall container could create a fire hazard. Suitable lining, such as polyvinyl alcohol or polyvinylidene chloride, however, could eliminate this problem.

Automobile sunvisors lend themselves to this type of fabrication quite readily. These units are being produced commercially in Europe and are being investigated by producers of automotive parts here in the United States.

Other possibilities in the automotive market, keeping in mind both the limitation of the process and of the materials to be used, include gas tanks, air cleaners, arm rests and glove compartments. ■

A Cost Comparison: Die-Cast Metal versus Molded Plastic Parts

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Die casting of metals has been widely applied as a means of producing complicated shapes which may or may not be required to support structural loads. In many cases their function is partly or exclusively decorative. Now plastics quite generally are adapted to the production of decorative shapes, and some plastics, depending on their individual strength properties, are suited to the production of load-bearing parts. It therefore has seemed reasonable that preliminary surveys should be made to determine to what extent the particular types of plastics might offer practical advantages over die castings. Three types of plastics which have been investigated are the conventional acrylics, the newer high-impact acrylics and the polyesters.

An evaluation of their intrinsic properties shows clearly that in many applications where die castings have traditionally been used, such plastics can meet the physical requirements *when proper design principles are followed.* Furthermore, it has been shown that in most cases parts can be designed to give adequate strength without a prohibitive increase in volume over that of a metal part performing the same function. The specific gravities of these plastics are much lower than those of die castings alloys so that the plastics parts, even at increased thicknesses, are still lighter in weight than the metal ones.

Following are case history studies of a group of parts selected from the wide variety offered by the automotive field. The studies offer a dependable evaluation of the cost factors involved in the replacement of some typical die-cast parts by plastic moldings.

Case Studies

Automobile Instrument housing—1

This die casting, used on the dash of a popular car, consists of an oval housing with three circular pod openings for instrument dials. Its weight in zinc alloy is 4.7 lbs. Using the die-casting molds with necessary gating changes, similar parts were actually molded of high-impact acrylic. From examination of these parts, it was concluded that redesign of the part to provide adequate strength would require increasing the average wall thickness from 0.60″ to .100″. On this basis, the following costs were calculated:

Zinc Alloy Die Casting

Operation	Estimated Labor, Hours Per Thousand Parts
1. Die Cast	27
2. Die trim to remove excess metal	12
3. Sand to remove burrs	15
4. Drill eleven holes (gang drill)	12
5. Inspect holes for allignment and general appearance	12
6. Drive all studs automatically	12
7. Dichromate treat	10
8. Paint inside and out	20
9. Inspect and pack	12
	122

Item	Cost Per Thousand	
Labor (122 hrs. @ $2.30)	$280.60	
Overhead (300%)	841.05	
Material (Zn alloy @ $.125/lb.)	583.75	
Shipping containers (4 to box)	60.00	
Total Cost Per Thousand		$1,765.40

Die Costs (6 @ $18,000) = $108,000

Molded High Impact Acrylic

Operation	Estimated Labor, Cost Per Thousand Parts
1. Mold	17
2. Drill holes	12
3. Inspect holes	12
4. Drive studs	12
5. Paint in and out	20
6. Inspect and pack	12
	85

Item	Cost Per Thousand	
Labor (85 hrs. @ $2.30)	$195.50	
Overhead (300%)	585.75	
Material (acrylic @ $.56/lb.)	765.00	
Shipping Containers (4 to box)	60.00	
Total Cost Per Thousand		$1,606.25

Die Costs (6 @ $16,000) = $96,000

Window Switch Escutcheon—2

In contrast to relatively large parts, there was interest in evaluating the cost relationship for much smaller items which might be used in large enough numbers to require a substantial volume of material. For this purpose an automobile window switch escutcheon, roughly 2 inches square, with a square cut-out approximately ¾ inch on a side, was chosen. Using procedures similar to those detailed above, the following overall costs, exclusive of finishing, were determined:

Material	Cost Per Thousand
High Impact Acrylic colored	$ 62.76
High Impact Acrylic natural	61.27
Zn Alloy	66.50

Conventional Acrylic

In many assemblies which have been designed to include die castings, improved appearance and function could be achieved by taking advantage of the transparency and optical clarity of the conventional acrylics. Imaginative use of sound design principles can meet the structural requirements of such parts and at the same time give them new beauty and variety of appearance. Principal approaches in this direction are first, the use of second surface decoration to provide texture and detail in opaque areas, and second, integration of clear areas with bezels and backgrounds, in one-piece moldings.

Instrument Overlay Panel—3

This large automobile dash panel in zinc alloy was 6 inches by 36.5 inches by .065 inch thick and weighed 3 lbs. For comparison, the molder postulated injection molding a corresponding part in clear acrylic, with second-surface plating and painting to provide texture and decoration. To insure adequate strength, an increase in nominal thickness to .100 inch was assumed. At this thickness, the acrylic part would weigh only .857 lbs. (13.7 oz.), saving over 2 lbs.

Production runs of 100,000 pieces were assumed, with a setup charge of $700 for each run. Production rates were estimated at 1,175 parts per day in a two-cavity mold.

Operation	Hours Per Thousand	Cost Per Thousand	
1. Injection Molding	20	$ 46.00	
2. Drill 9 holes	15	27.60	
3. Vacuum metallizing	4	9.30	
4. Painting	20	46.00	
5. Inspect and pack	15	34.50	
	74	$163.40	
Overhead (500%)		$817.00	
Material (Acrylic @ $.55/lb.)		470.00	
Shipping Container		65.00	
Setup Charge		7.00	
Total Cost Per Thousand			$1,522.40

Two-Cavity Mold—$25,000

Comparative figures could be worked out for this part in a zinc die casting. Instead, a quotation was obtained from two commercial sources. They agreed on a cost for this part of $2,000 per thousand. Therefore, the use of acrylic in this application offers savings of $477.60 per thousand parts, or $.48 per panel.

Truck Fender Ornament—4

The familiar ornament used on the fender of a popular truck model offered an opportunity to learn more about the comparative costs of large medallions. This part, over 14 inches long and 6 inches wide in some spots, was originally assembled from 3 separate die castings. In order to obtain a fair comparison, the design group of a plastics supplier was asked to modify the die casting prints into a design for a single molded part to replace all three castings. This design called for mounting the acrylic part by means of a mastic adhesive and a stamped metal back plate, an accepted procedure for such applications.

These revised drawings were then submitted to molders for quotations and the results were compared with estimates for the costs of the die-cast assembly.

Zinc Alloy Die Casting

Estimated Weight: 1.5 Lb.

Operation	Hours Per Thousand	Cost Per Thousand
1. Die cast molding (a)	12.5	
Die cast molding (b)	4	
Die cast molding (c)	2.5	
	19	$ 43.70
2. Trim (3 parts)	16	36.80
3. Drill holes	10	23.00
4. Drive studs	10	23.00
5. Polishing	16	36.80
6. Plating (3 parts)	10	23.00
7. Buffing	16	36.80
8. Painting	20	46.00
9. Inspect and pack	13	29.90
Total	130	$299.00
Overhead (300%)		$897.00

(Costs continued on next Page)

Material (Zn Alloy @ $.125/Lb.)	187.50	
Shipping Containers (3)	75.00	
Total Cost Per Thousand		$1,458.50

Die Cost (Two Cavity) $20,000
Trim Dies $5,000
Painting Fixtures $5,000

Molded Acrylic

Weight: 0.32 Lb.

Operation	Hours Per Thousand	Cost Per Thousand
1. Injection molding	12	$ 27.60
2. Painting	17	39.10
3. Vacuum metallizing	3	6.90
4. Back coat	9	20.70
5. Mastic and back plate	16	36.80
6. Inspect and pack	11	25.30
Total	68	$156.40

Overhead (300%)	$469.20	
Material (acrylic @ $.55/lb.)	176.00	
Back plate metal and mastic	25.00	
Shipping Container	75.00	
Total Cost Per Thousand		$ 901.60

Mold Cost (Two Cavity) $18,000
Plating Masks and Fixture $10,800

Die Casting	$1.458
Molded Acrylic	.902
Cost Savings	$ .556 per part

Reinforced Polyester Resins

Air Deflector—5

Samples of four typical reinforced polyester premix moldings which had actually replaced zinc alloy die castings were obtained. From examination of these parts, a hypothetical premix formulation was established which would meet the requirements of the applications:

Suggested Formula

Polyester resin	33	parts
ASP-400 Clay	52	parts
Glass Fibers–¼"	15	parts
Mapico Black Pigment	2	parts
Zinc Stearate	1	part
Benzol Peroxide (50%)	0.33	parts

Premix Costs

	Ko-Kneader	Sigma Blade Mixer
Total raw material cost	$18.28/cwt	$18.57/cwt
Total cost of premix compound	19.42/cwt	21.82/cwt

Processing Costs

	Hours Per Thousand	Cost Per Thousand
1. Mold (40 sec. cure & 23 sec down)	17.5	$ 43.75
2. Inspect and Pack	6	15.00
	23.5	58.75
Burden (300%)		176.25
Total		$235.00

Finished Cost in Polyester

	Ko-Kneader	Sigma Blade Mixer
Premix Cost	$ 36.00	$ 40.00
Processing Cost	235.00	235.00
Total Cost Per Thousand	$271.00	$275.00

A corresponding calculation was made for the same part in zinc alloy XXIII, asuming in this case that an equivalent cross-section would be needed.

Die Casting Costs

	Hours Per Thousand	Cost Per Thousand
1. Mold	8	$ 20.00
2. Trim	6	15.00
3. Inspect and Pack	5	12.50
	19	$ 47.50
Burden 300%		142.50
Material @ $.125/lb.		93.00
Total Cost Per Thousand		$283.00

Plastics Have the Edge

Still further advantage should be realized in plastics parts designed to exploit their particular capabilities instead of merely duplicating the shape and appearance of a metal part. Some of the more important considerations in this direction are integration of parts, use of simpler and faster mounting or assembly methods, incorporation of surface texture and finish not attainable in metals, and use of mastic attachment.

Considering this data to be representative, it is our conclusion that wherever the properties of conventional or high-impact acrylics or of reinforced polyesters are admissible, they are likely to offer savings in cost over die-castings. Such savings are especially probable when plastics can be introduced at the original design state to take full advantage of their specific properties.

Laminates do not have a pure coefficient of linear expansion. The reason: Shrinkage occurs due to changes in moisture content. This article gives a test method which is reproducible between laboratories and which measures the change in length and temperature simultaneously.

Use of Thermoset Laminated Plastics in Electronic Applications

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In the past much work has been done in evaluating the physical and electrical properties of laminated plastics separately. The effect of changing environmental conditions on the physical and electrical properties has also been quite extensively studied. Now that the circuit wiring is bonded directly to the laminate, minor changes in the physical characteristics of the laminate can and do effect the performance of the circuit. Therefore, it becomes necessary to study the relation between physical change characteristics of the laminate and the functioning of the circuit.

One physical characteristic of laminates, which effects the performance of electronic circuits, about which a limited amount of knowledge has been gained, is linear thermal dimensional change. It has been found that laminates do not have a pure co-efficient of linear expansion. When tested in accordance with the Standard Method of Test for Co-efficient of Linear Thermal Expansion of Plastics, American Society for Testing Materials Designation D 696, a figure, reputed to be the coefficient of expansion is obtained. This figure has been published in many specification sheets. This test does not take into account an important characteristic of laminated plastics. When a laminate is subjected to elevated temperatures, a slight degree of linear shrinkage occurs simultaneously with thermal expansion. This is evidenced by the fact that when the laminate is returned to its original temperature, its linear dimensions are slightly less than before heating.

The shrinkage which occurs in thermoset laminated materials is due to changes in moisture content, state of cure (degree of polymerization), loss of plasticizers or solvents, release of stresses and other factors.

Several years ago the Motorola Laboratories in Chicago, Illinois, devised a test which has great value in studying the characteristics of laminates which can best be described as linear thermal dimensional change. In cooperation with The Richardson Company Laboratories in Melrose Park, Illinois, this test was evaluated and found to be quite reproducible between laboratories as well as being reproducible within a single laboratory. A detailed description of the equipment used in this test and the method found applicable to thermoset laminates is given in the box.

In this test the change in length of a test specimen and the specimen temperature are measured simultaneously, numerous times as the specimen is being heated and cooled. Using this data it is possible to plot unit dimensional change vs. temperature and thereby be in position to study the thermal dimensional change characteristics of the material. For convenience it has been found best to use plain coordinate graph paper. The temperature is plotted on the X axis and the unit dimensional change on the Y axis with zero change value being at the mid-point of the Y axis.

When a material having a true coefficient of expansion, such as steel, is tested in accordance with this method, the results form a single straight line as would be expected. The dimensional change is in direct relation to the specimen temperature.

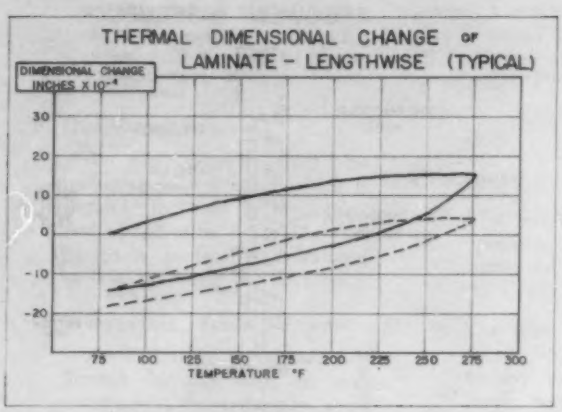


Figure 1

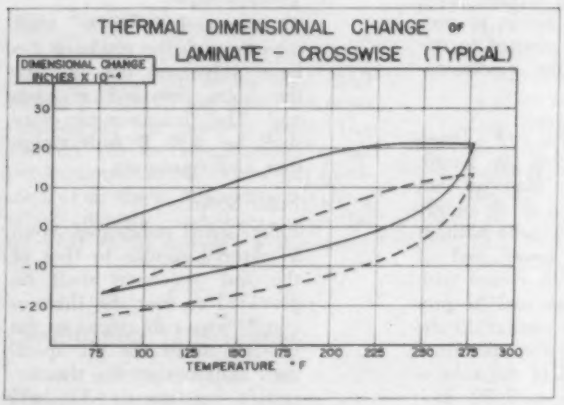
Figure 1 depicts a typical curve obtained when a specimen of laminate, cut in the lengthwise direction of the sheet, is tested. The solid line is the data obtained during the first heating and cooling cycle. The dash line is the data obtained in the second cycle. If cycling is continued, each successive curve more nearly approaches a single straight line and the length of the specimen at the end of the cycle more nearly approaches the length at the start of the cycle.

Conventional laminates are made by laying up the reinforcing webs in such a manner that the main or machine direction of each web is parallel to that of every other web in the finished sheet. As is to be expected, this results in the properties of the sheet in the main or lengthwise direction being somewhat different than in the crosswise direction. As can be seen in *Figure 2*, this anisotropy is apparent also in this thermal dimensional change test.

It has been found that each grade and brand of laminate has its own characteristic curve or hysteresis loop. The slope and openness of the loops will vary for each grade and brand but the shape is typical and the slope and openness of the loop obtained in the lengthwise direction is always greater than in the crosswise direction. Within a given brand of laminate the openness and slope of the loop will vary slightly if variations are made in the manufacturing process.

Much valuable information can be gained by studying these hysteresis loops. At the start of the cycle it appears as though a true coefficient of expansion curve is being developed. This has been disproven by running the test at lower top temperatures. When lower top temperatures are used there is very little openness in the loop and the shrinkage evidenced between the start and end of the cycle is small, but there is a loop nonetheless. At some point during the heating portion of the cycle there is apparently a break point where expansion is rapidly being offset by contraction. All laminates exhibit this break point to a greater or lesser degree. In some materials it is scarcely discernible while in others it is so pronounced that contraction actually overtakes expansion resulting in a downward slope during the end of the heating portion of the cycle. At the start of the cooling portion of the cycle a pronounced shrinkage occurs and then levels off at the lower temperatures. A pronounced break point during heating will result in a pronounced shrinkage at the start of cooling. At the end of the cycle a permanent shrinkage is evident.

Figure 2



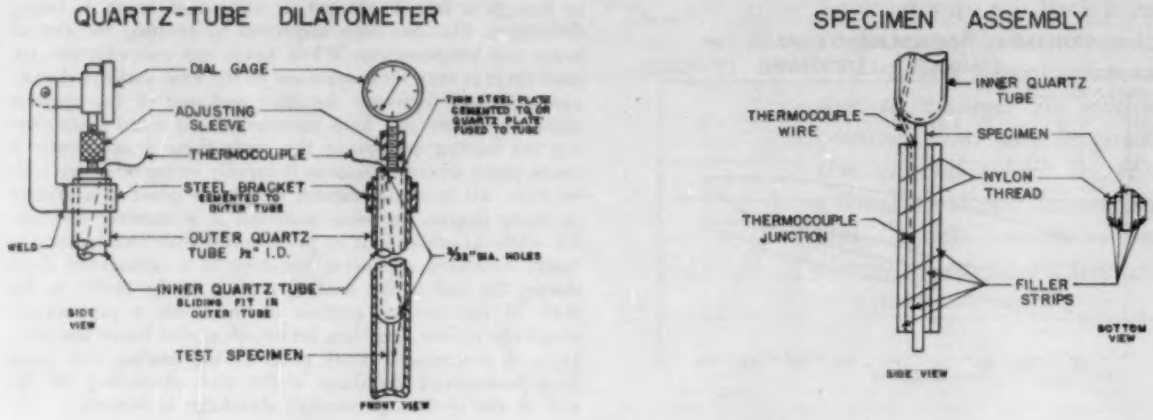
Factors in Punching Laminates

Information gained from the test can be used to explain and thereby resolve some of the difficulties encountered in punching laminates. If the material is being heated in strips prior to punching and then being fed into an unheated die, the dimensional tolerance of the punched parts will vary from the first part to the last part, as the first part will be punched at very nearly the top heating temperature but the last part will have cooled slightly, and this cooling is represented by the steep portion of the cooling curve. If the grain direction of the strip to be punched is changed, the difference in shrinkage in the two directions is compounded by the difference in the slope of the initial portion of the cooling curve. A cold punched part will not show this type of variation during punching, but it will be less dimensionally stable in service than a hot punched part as it has not gone through the first heating cycle.

It has been found that the changes in spacing between conductors in a printed wired circuit used in very critical applications will effect the performance of the circuit. Here the information gained from a study of the curves for the particular laminate in question quickly indicated an optimum stabilizing cycle to be a temperature just above the break point of the heating curve for a short time, rather than a lower temperature for a much longer time. A study of the curves also clearly demonstrated why difficulties were being encountered in a printed circuit being used in a critical application when the grain direction of the supporting laminate was not being taken into account.

What are the Needs?

Thermoset laminate plastic materials have served the electronic industry well in the past and can continue to do so provided the laminate manufacturer recognizes the need for more functionally reliable materials and the electronic engineer is informed of all characteristics of this material, its limitations as well as its merits. The laminator can develop materials with better permanence properties by proper selection of raw materials, formulations and process conditions; he can also produce more reproducible products by manufacturing them in a repetitious manner and not trying to test quality into the product through the use of in-process and finished product control tests. The electronic engineer can make better use of laminate materials if he will, in cooperation with the material supplier, study all aspects of the material rather than limiting his scope of interest to only the electrical properties.



Equipment used in test method described below

Test Method For Determination of Linear Thermal Dimensional Change Characteristics of Plastics.

Definition:

The linear thermal dimensional change of a plastic material is the change in dimension of the plastic material resulting when it is subjected to varying temperature conditions. This dimensional change is a composite of thermal expansion and the contraction which is due to changes in moisture content, state of cure (degree of polymerization), loss of plasticizer or solvents, release of stresses and other factors.

Scope:

This method of tests is intended for determining the combined linear thermal expansion and the contraction characteristic of plastic materials over prescribed temperature ranges. The temperature ranges to be used when testing thermoset laminated plastic materials shall be 25°C to 140°C (77°F to 284°F).

Apparatus:

A. Quartz tube Dialometer with following parts:

1. Outer Tube:
   An outer tube of fuzed quartz 20 inches in length, ⅞ inch in inside diameter, and about 2 mm in wall thickness. The tube is sealed on the lower end, the sealing surface being convex on the inside to provide one-point contact to the lower end of the specimen.

2. Inner Tube:
   An inner tube of fuzed quartz 16 inches in length with an outside diameter that allows this tube to fit snugly inside the outer tube without binding. The lower end of the inner tube is closed with a hemispherical seal to provide one-point contact to the upper end of the specimen. The lower end of the tube is provided with a 3/32 inch diameter hole to accommodate the thermocouple wire. To the upper end of the inner tube, is attached a thin steel plate, or is fuzed a quartz plate which serves as a rest for the foot of the dial gauge. This plate too is provided with a 3/32 inch diameter hole.

3. Thermocouple:
   Thermocouple wires shall pass through the inside of the inner tube and out through the holes provided at each end. The thermocouple wire shall be #30 B & S gauge iron and constantin.

4. Filler Strips:
   Filler strips fabricated from a material similar to that of the test specimen shall be provided so that the thermocouple wire can extend to the central portion of the specimen and so that the thermocouple junction can be held

in juxtaposition to the surface of the specimen. The filler strips shall be 3-¾ inches in length.

B. Dial Gauge

A dial gauge shall be mounted on a bracket which is securely fastened to the upper end of the outer tube. The dial gauge is preferably calibrated to 0.0001 inches per division.

C. Temperature Sensing Device:

An indicating pyrometer calibrated for use with an iron constantan thermocouple shall be used.

D. Scale or Caliper:

A scale or caliper capable of measuring the length of the specimen with an accuracy of plus or minus 0.01 inches shall be provided.

E. Low Temperature Bath:

A liquid bath maintained at a temperature of 25°C (77°F) shall be provided. Means shall be provided for stirring the bath and for controlling its temperature within plus or minus 0.5°C (1°F).

F. High Temperature Bath:

A liquid bath maintained at a temperature of 145°C (293°F) shall be provided. This shall be similar in construction to the low temperature bath and must be capable of maintaining its temperature within plus or minus 1.0°C (2.0°F). Caution: If different liquids are used in the two baths the dilatometer tube must be wiped dry after removal from one bath and before insertion into the second bath.

Test Specimens:

Specimens ½ inch wide by 4 inches long by the material thickness shall be cut from both the main and cross direction of the laminate sheet. The ends of the specimens must be cut perpendicular to the axis of the specimen. For thick laminates the long edges of the specimen may be rounded to fit loosely in the outer tube.

Conditioning of Specimen:

Test specimens shall be conditioned 24 hours in an atmosphere having a relative humidity of 50% plus or minus 2% at a temperature of 25°C plus or minus 1°C (77°F plus or minus 2°F) prior to testing.

Procedure:

A. The length of the conditioned specimen shall be accurately measured at room temperature 25°C (77°F)

B. The filler strips with the thermocouple junction shall be attached to the specimen and firmly secured with a thin nylon thread. Sufficient silicone oil shall be added to the outer tube to completely cover the specimen. The inner tube with the specimen filler strip assembly attached shall be inserted in the outer tube making sure that no binding occurs and that the specimen firmly contacts the bottoms of both the inner and outer tubes. The thermocouple leads shall be connected to the temperature sensing device.

C. The dilatometer assembly shall be immersed in the low temperature bath to a minimum depth of 12 inches. When the temperature of the surface of the specimen, as indicated by the temperature sensing device, is 25°C plus or minus 1°C (77°F plus or minus 2°F), the dial gauge shall be preloaded sufficiently to allow for a 0.02 inch contraction of the specimen and the dial gauge set to zero.

D. The dilatometer shall be removed from the low temperature bath and immediately immersed in the high temperature bath to a minimum depth of 12 inches. Care must be exercised not to disturb the apparatus, the dial setting or the specimen during the transfer.

Readings on the dial gauge shall be recorded when the surface temperature of the specimen as indicated by the temperature sensing device is 25, 35, 50, 65, 80, 95, 110, 120, 130, 135 and 140°C (77, 95, 122, 149, 176, 203, 230, 248, 266, 275 and 284°F).

E. When the surface temperature of the temperature reaches 140°C (284°F), the dilatometer shall immediately be transferred from the high temperature bath to the low temperature bath.

Readings on the dial gauge shall be recorded when the surface temperature of the specimen is 140, 135, 130, 120, 110, 95, 80, 65, 50, 35 and 25°C (284, 275, 266, 248, 230, 203, 176, 148, 122, 95 and 77°F).

F. When the surface temperature of the specimen reaches 25°C (77°F) immediately repeat steps D and E of Section VI.

G. Continue the cycling until the dial readings at the lowest temperature of two successive cycles is substantially the same.

Calculation and Report:

A. Calculation:

The unit linear dimensional change shall be calculated for each reading of the dial gauge as follows:

$$\text{Unit Dimensional Change} = \frac{\text{Dial Reading}}{4}$$

B. Report:

The report should include the following:

1. Designation of material, including name of manufacturer and information on composition when known.
2. Dimensions of test specimen taken at room conditions.
3. The direction of the specimen in relation to the material from which it was cut.
4. The recorded dial readings and the surface temperature at which the readings were taken.
5. The unit change of length of the material and the surface temperature of the specimen at which the unit changes in length were calculated.
6. Plot of the unit change in length vs. temperature on plain coordinate graph paper with the unit change being the Y axis and the temperature being the X axis.

The steel industry uses large amounts of plastics in construction, but primary development is concentrated on combining steel and plastic to achieve results not possible with either material alone.

Plastics as Construction Materials in the Steel Industry

Joseph Bigos *Applied Research Laboratory U. S. Steel Corporation*

Before considering the use of plastics as construction materials in the steel industry, it is well to recognize that plastics are competitive materials that aggressively seek to displace steel from many of its present end uses. Therefore, it is natural that the steel industry should regard the use of plastics as construction materials from a viewpoint different from that of the producers of plastics. Current research and development on the part of steel companies on the use of plastics as construction materials is aimed primarily at the utilization of plastics in conjunction with steel to combine the strength, utility and low price of steel with the decorative, protective and functional features of the plastics. In this way, they seek to increase the use of steel by the production of new or improved products.

But there is another aspect to consider: the steel industry is a great consumer of products. There can be cited numerous instances where plastics construction materials are used in the steel industry, and the reason for their use is based upon the intrinsic merits of the plastics.

Miscellaneous Examples of the Use of Plastics

Skylights made of plastics represent a usage of plastics as construction materials that displaces some steel products, but usage endorsed by the industry in its own construction program because of certain advantages gained by the use of the plastics. Moreover, the market for steel sheeting and roofing probably is increased because economical skylights make steel buildings more desirable and lead to the construction of more buildings made of steel. In the steel plants, most of the plastic used for skylights is corrugated fiberglass-reinforced polyester. This material is most often used with conventional sheeting and must have a profile that permits it to be lapped with formed galvanized steel roofing and siding. The obvious requirements of ultraviolet-light stability, weatherability, impact resistance and crack and craze resistance by the plastics are being met in a much better manner today. The result has been a diminishing of the bad reputation developed by some of the poorer plastics materials previously sold as "permanent." Although the uninstalled price of corrugated fiberglass-reinforced plastic roofing or siding is four to five times the price of galvanized steel, the functional use of the plastic for the passage of light will continue, but it is not likely to supplant the use of steel sheeting for roofing and siding material.

Sealants utilizing various types of plastics represent a significant use of plastics in buildings. The current trend to curtain-wall construction has greatly expanded the problem of adequately weatherproofing buildings. There are many plastics sealants available and in use by industry today, but there are few really good ones. A really good one should last the life of the building and be applied without undue difficulty. In addition to the older caulking compounds, large amounts of butyl rubber, neoprene, and polysulfide-based sealants are used. Considerable interest in polyurethane sealant has been aroused because of its excellent handling, sealing, and weathering properties. Certainly, some of the synthetic materials will have sufficient resistance to ultraviolet light and the weather to permit them to be classed as permanent.

Adhesives must be mentioned because they are used extensively as construction materials. Examples of their

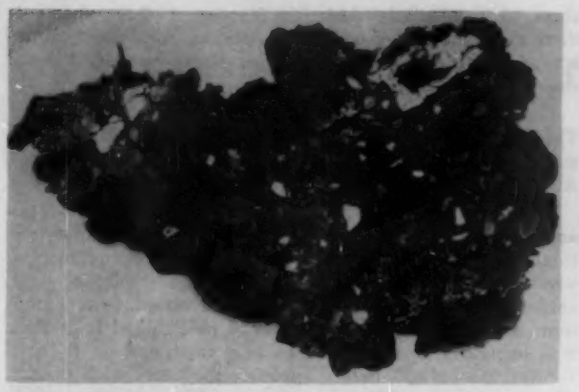


Figure 1. Section of blast-furnace burden removed after impregnating with plastic.

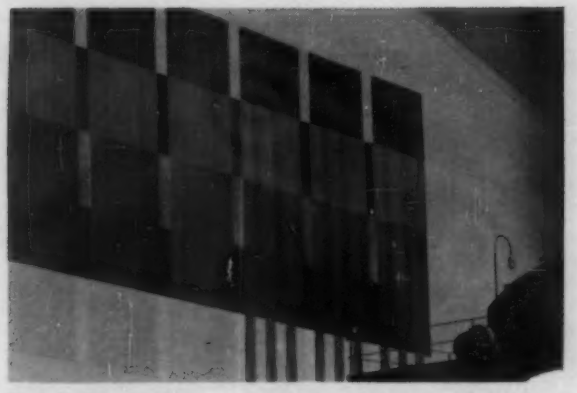


Figure 2. Vinyl-coated steel used on sintering plant.

use include fastening insulation to roofs and walls; bonding cored panels; holding floor, wall, and ceiling tile in place; laminating films or sheets to steel; joining plastic pipe; joining metals to metals or to masonry. However, so many adhesives are used in so many places that we cannot itemize them. All the various classes of thermoplastic, thermosetting, and elastomeric adhesives are used in steel plants today. These uses are mostly conventional ones requiring only minor modifications for use. However, an unfilled need exists for structural adhesives capable of joining sheet steel with bonds equivalent in strength to those of production welding and riveting. In this connection, high peel strength of the joint is mandatory.

Plastics insulation competes strongly with fiberglass and the older, more conventional insulating materials. In sandwich-type construction of built-up mill roofs, insulation is often used between two corrugated galvanized steel sheets; such insulation must be flexible. Much plastics insulation is being used in building panels where it is highly desirable because it can be foamed in place. Rigid, semirigid, and flexible foams, such as the polyurethanes, are cut to fit or foamed in place, as required. In addition, large amounts of polystyrene and polyvinylchloride foamed plastics insulation materials are being used because of their low thermal conductivity, shock and crumbling resistance, light weight, strength, and waterproofing characteristics. Waterproofing requirements often dictate certain moisture-vapor transmission rates; plastics foams are adaptable to this requirement because of the possibility of controlling the foam to produce open or closed cells.

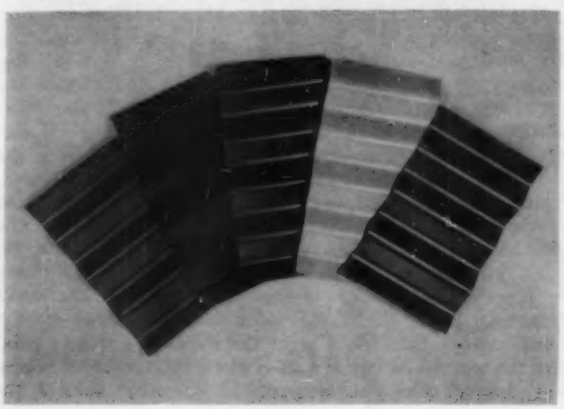
Figure 3. Steel warehouse with vinyl-coated steel exterior and plastic daylinghts.

Research on Utilization of Plastics

The U. S. Steel Corporation is a large user of plastics and is conducting research on new ways to utilize plastics materials. Much of this work is aimed at methods of application, such as the fluidized-bed technique in which hot steel is immersed in a fluidized bed of powdered thermoplastic resin. Another technique that has been explored is the vapor deposition of plastics on steel. Naturally, application of 100 per cent solids constitutes a basic goal, and considerable success has been achieved in depositing vinyl plastisols and vinyl resin powders in laboratory, pilot-plant and semicommercial processes. Research has also been conducted on the application of plastic coatings to steel strip at high speeds and short curing times by using very high curing temperatures far above the decomposition temperatures of the organic materials.

In all this work, the goal is to combine steel with plastics to achieve an improved end product. One such development is a plastisol-coated steel hardware cloth that is used in building chicken coops; the eggs are dropped by the hens on the resilient surface and roll to collecting stations. Steel window sash with various plastics coatings is also being tested to determine whether the coatings will have sufficient permanence. Various plastics are in different stages of development as clear or colored coatings for stainless steel. Strippable plastics coatings for stainless steel are now in use and have been developed to the point where they remain strippable and do not pit the surface of the steel. Wire-mesh fence is receiving attention; plastics coatings have been developed and are in field trials. Wire-

Figure 4. Corrugated vinyl-coated steel sheets.



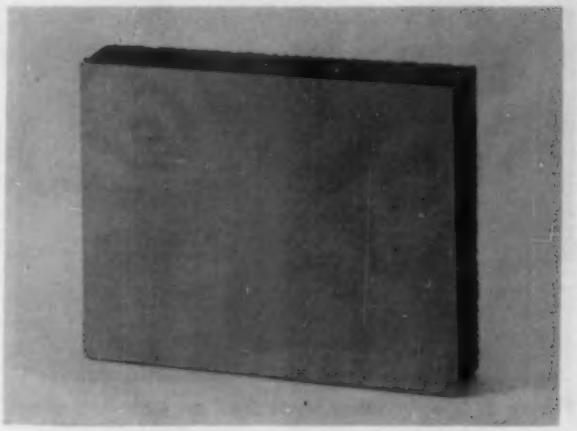


Figure 5. Building panel of vinyl-coated steel.

cloth screening presents a difficult problem that is being investigated; here, materials are being sought for use in coating steel wires that can then be woven into insect screening of high strength and durability.

A rather novel use of plastics in the steel industry is illustrated in *Figure 1*. To get a look at what really goes on inside a blast furnace, an experimental blast furnace was "frozen" by quenching the burden with steam and nitrogen and then drying the burden in place. A catalytically cured epoxy resin was used to impregnate a central core of the burden by pouring the plastics into sections of the burden. In all, 18 sections were removed, and these constituted a 22-foot-long sample of the "insides" of the blast furnace. These samples were cut, polished and examined petrographically. The results showed for the first time the various conditions of the burden and its components as they move down through the blast furnace.

Vinyl-Painted Steel

A fine example of the utilization of plastics to improve the life performance of steel roofing and building sheets exists in vinyl painting. *Figure 2* shows an over-all view of a new sintering plant. This plant, which includes millions of square feet of protected steel siding and roofing, is typical of current construction in the Corporation.

Vinyl-painted steel utilizes vinyl plastic resin applied in the form of pigmented lacquer-type coatings by conventional air-spray techniques. The term **vinyl-painted steel** is used to differentiate this construction material with its thin coating of vinyl plastic from the quite different **vinyl-coated steel**, which has a much heavier plastics coating.

The noteworthy feature of vinyl-painted steel is the synergistic effect achieved by the utilization of a very thin plastic coating with a thin protective metal coating. The dry film thickness of the vinyl is 1.5 to 1.75 mils; this thickness is inadequate to protect steel from corrosion for very long; undercutting by rust destroys the vinyl film. Metallic zinc is used to provide economical, sacrificial protection to the steel in galvanized steel sheets. The life of the sheet is limited because the zinc corrodes; in some environments, the zinc is attacked and sacrificed rather quickly. In combination, the vinyl plastic protects the surface of the zinc coating so that the corrosion rate of the zinc is negligible, and the zinc permits long life of the thin vinyl film by eliminating corrosion of the steel substrate. The result is that the life of the vinyl-painted galvanized steel sheet is much greater than the sum of the lives of the vinyl paint and the zinc when either is used alone on steel. As a bonus, any desired color can be supplied on either side of the sheet. A particularly desirable feature of these sheets is their excellent fire resistance; they have the lowest flame-spread and fuel-contributed ratings of any protected metal sheets tested by the Fire Underwriters Laboratory.

Galvanized steel is not the only product that is painted. The vinyl plastic is used considerably on terne-coated steel and also on aluminum-coated steel and on stainless steel. All the sheets are corrugated before painting.

Satisfactory pretreatment of the sheets is necessary to achieve adequate adhesion of the vinyl. Wash-primer pretreatment, consisting of a basic zinc chromate pigmented vinyl butyral binder acidified with phosphoric acid, achieves excellent bond to properly cleaned zinc, aluminum, and terne surfaces. Because of mechanical limitations it is expedient to use a Bonderizing treatment on the galvanized steel sheets before applying the vinyl wash primer. This combination of pretreatments is required to achieve sufficient adhesion of the vinyl plastic to prevent blocking of the sheets in the bundles during storage with resultant pulling of the vinyl from the surface.

After the wash-primer pretreatment, the sheets are dried in an oven at 200°F to 300°F for a period of 1 to 4 minutes before application of the first of two vinyl topcoats. These vinyl coatings are slightly plasticized solutions of copolymers of vinyl chloride and vinyl acetate pigmented with titanium dioxide, iron oxide, or aluminum. The first

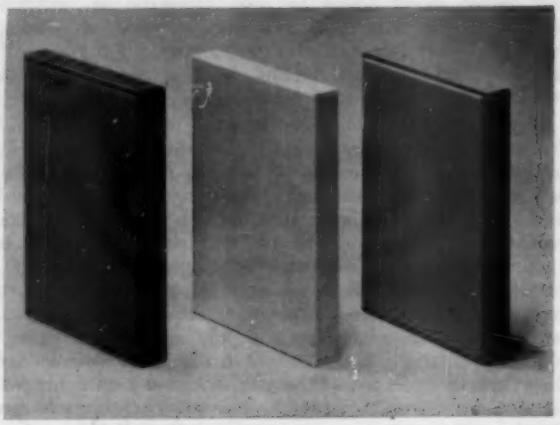


Figure 6. Models of building panels with vinyl-coated steel and plastic insulation.

Figure 7. Vinyl-coated steel door.

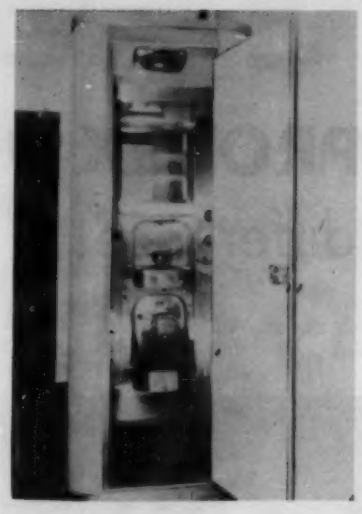


Figure 8. Lavatory unit made of vinyl-coated steel.

vinyl topcoat is dried for 3 to 9 minutes in the oven before the final coat of vinyl is applied. The entire vinyl system is dried after application of the second topcoat. The two sides of the sheets are often painted with different colors; brown may be used on the outside to blend with the color of iron-ore deposits, and the inside is painted aluminum for better reflectivity. *Figure 2* shows a close-up of the vinyl-painted sheets during construction of the sintering plant. The brightly colored sheets are test installations of the next product to be discussed.

Vinyl-Coated Steel

Vinyl-coated steel is a new, versatile construction material combining the color, texture, and protection of plastics with the strength of steel. However, its use by U. S. Steel on the sintering plant is experimental only and the ability of the vinyl coating to withstand outdoor weathering for the long periods of time desired for materials of construction remains to be proved. Outdoor tests of several years duration showed some loss of color, principally with the reds, but no loss in durability or structural strength. Another trial use of vinyl-coated steel on a structural exterior is shown in *Figure 3*. The end of this warehouse is sheathed with vinyl-coated steel formed after coating. After two years exterior exposure, the vinyl has retained its appearance and bond, and the protected steel shows satisfactory indications of performing in the anticipated manner. This building also has fiberglass-reinforced polyester plastic corrugated to match the sheeting and installed in the walls to light the interior.

Figure 4 is a close-up of sections of corrugated building sheets made of vinyl-coated steel.

This vinyl coated steel is produced by a roller-coating process that produces superior adhesion due to inclusion of a thermosetting plastic adhesive that is applied to a clean, electrochemically treated surface in coil or sheet form. As a result, the vinyl coatings exhibit outstanding adhesion, even after severe deformation. Following 30 to 35 per cent elongation of the coated-steel test specimen in a standard quality-control test, the vinyl plastic coating must withstand a pulling force of at least 22 pounds per inch of width without parting even after immersion in boiling water and exposure to high humidity or high heat. The ability to adhere and resist deformation is shown by the appearance of the specimen; much more severe fabrication can be withstood.

The vinyl coating is applied in the form of a plastisol, which is cured primarily by induction heat and secondarily by radiant heat. After curing, the surface is embossed, cooled, and either cut to length or recoiled.

Cold rolled steel of suitable quality for the end use is used for most applications. When extra corrosion protection is required, galvanized steel is used. The reverse surface of the sheets is protected by vinyl, epoxy, or acrylic coatings, by electrodepositing metal, or by a chemical treatment. When edges must be protected, galvanized steel can be used or the edges may be painted.

For indoor application, vinyl-coated steel has limitless possibilities as a material of construction. *Figure 5* shows a steel wall panel of high strength that makes considerable use of plastics. The exterior faces of the panel are vinyl-coated steel of a color and embossing chosen to fit the design. The core consists of a lightweight, plastic-impregnated paper honeycomb. The core is bonded to the steel surface by means of a plastic adhesive that also provides corrosion protection to the reverse surface of the vinyl-coated steel.

Figure 6 shows model wall panels made by brake forming the vinyl-coated steel. Plastic insulation, cut-to-fit or foamed-in-place, is easily inserted in the panel. Another use of vinyl-coated steel is demonstrated in *Figure 7* where the vinyl-coated steel is used for facing an office door.

A number of U. S. Steel mill-offices are being equipped with the unitized lavinette as illustrated in *Figure 8*. This unit contains a washbowl, toilet, and shower. Vinyl-coated steel and stainless steel are used as the exposed materials of construction. These are but a few of the uses of vinyl-coated steel in buildings.

Pipe and Tubing

The last field to be covered concerns pipe and tubing. Galvanized steel pipe in domestic water service lost ground rapidly to copper tubing, even though galvanized steel pipe is less expensive than copper tubing. Copper tubing and plastic pipe have taken much of the domestic market away from cast-iron and steel pipe.

The steel industry, through the American Iron and Steel Institute, sponsored research work at Battelle Institute to develop plastic coatings for steel pipe for hot-and-cold domestic service. Epoxy and phenolic coatings, or combinations of them, have been developed; some of these are believed adequate for the service. Now the steel companies are considering the practicality of producing pipe lined with such plastics.

To gain background as a basic producer of chemicals for plastics, U. S. Steel began producing plastic pipe of polyethylene and high- and normal-impact polyvinyl chloride. This pipe is being used extensively in construction in cold-water service, in sprav systems, and as electrical conduit. It is used in the petroleum industry as it has excellent corrosion resistance to sour crudes and salt water. Other steel producers have successfully combined steel and plastic to obtain strong, corrosion-resistant pipe and tubing. Steel pipe is available lined on the inside or on the outside with polyvinylidene chloride, polyethylene, or polyvinyl chloride.

The U. S. Steel Corporation is conducting considerable research and development on combining steel with plastics. Large-diameter pipe has already been produced commercially with an outside coating of coal tar–epoxy; other pipe has been produced and coated on the inside with epoxy coatings. The application of polyvinyl chloride to small-diameter pipe by the crosshead extrusion method is in the developmental stage; it is anticipated that this pipe will have excellent resistance to soil corrosion or other corrosive environments.

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Speaking of Extrusion

Extruder Scale-Up Theory

Important factors to be considered in scaling up from small extruders

Having established an optimum design for a small extruder, one is frequently faced with a desire to construct a larger machine to produce the same or a similar product at a greatly increased delivery rate. Carley and McKelvey[1] have shown, in the case of isothermal or adiabatic melt extruders, that if all of the dimensions of the small machine are scaled up by a factor, x, then the larger one would be expected to deliver x^2 times the quantity of the smaller one at the same temperature and pressure. They also point out that for plasticizing extruders, that is, those in which the plastic is received as a solid which must be melted and mixed as well as formed into a desired shape, this goal is seldom, if ever, reached due to heat development limitations in the melting section toward the rear of the machine. The following discussion sets forth a number of important extruder characteristics which must be included in any consideration of scale-up and illustrate the expected results under several possible scale-up situations. One finally arrives at the conclusion that there is no ideal system and that a satisfactory compromise is one which has been used extensively by extruder manufacturers.

For purposes of discussion, we will assume a conventional metering type screw and consider mechanisms taking place in the metering section. We will also assume the ideal case where the feed and transition sections of the screw can supply molten plastic to the metering section at a rate equal to the delivery or pumping capacity of the metering section. The simplified flow equation for this condition is:

$$Q = \text{Open discharge rate} - \text{back flow} = \alpha N - \beta P \quad (1)$$

where:

Q = volume rate of discharge
N = screw speed
P = head pressure
α = drag flow constant = $\frac{\pi^2 D^2 h \sin\phi \cos\phi}{2}$

β = back flow factor = $\frac{\pi D h^3 \sin^2\phi}{12 \eta L}$

D = barrel diameter
h = channel depth at discharge
ϕ = helix angle
L = effective screw length
η = material viscosity in channel

For the conventional design where the lead is made equal to the diameter, the expressions for α and β can be reduced to:

$$\alpha = A D^2 h \quad (2)$$

and

$$\beta = \frac{B h^3 D}{L} \quad (3)$$

where A and B are constants independent of screw diameter or channel depth.

It can be shown that the expression for α is one half of the channel volume in the last or exit turn of the thread. The total volume in the exit turn is thus:

$$V_e = 2\alpha = 2 AD^2 h \quad (4)$$

and the total volume of material in a metering section m turns in length would be:

$$Vm = mV_e = 2 m AD^2 h \quad (5)$$

Similarly, if the effective screw length, L, is assumed to be equal to the length of the metering section, L = mD, and this value is substituted in (3), we get:

$$\beta = \frac{Bh^3 D}{\eta mD} = \frac{B^1 h^3}{\eta} \quad (6)$$

Let us now make one further idealizing assumption that by appropriate adjustment of the head pressure, the screw can be operated under a condition where the actual output rate is two thirds of the open discharge rate. This is an arbitrary selection but one which experience has shown will normally give satisfactory results. The net output rate at this point will be:

$$Qn = 2/3\, \alpha N = 2/3\, AD^2 hN \quad (7)$$

The residence time in the metering section will be given by:

$$t = \frac{\text{volume in metering section}}{\text{net output rate}}$$

$$\frac{2mAD^2 h}{2/3\, AD^2 hN} = \frac{3m}{N} \quad (8)$$

The shear rate in the metering section is defined as the surface velocity at the barrel wall divided by the channel depth, or:

$$\gamma = \frac{\pi D N}{h} \quad (9)$$

The total shear in the metering section, defined as the product of the shear rate and the residence time, is then:

$$S = \gamma t = \frac{\pi D N}{h} \cdot \frac{3m}{N} = \frac{3m \pi D}{h} \quad (10)$$

The cutoff pressure, that point where the back flow is equal to the open discharge rate and the actual output rate is zero, can be determined by setting $\alpha N = \beta P$ and solving for P. This gives:

$$Pc = \frac{A}{B^1} \eta \frac{D^2}{h^2} N \quad (11)$$

Most of the mechanical power delivered to the screw ends up as frictional heat in the material. It can be shown that the temperature rise due to frictional working is related to the product of the material viscosity and the rate of shear, in the following manner:

$$\Delta T = J\eta\gamma \quad (12)$$

where J is a constant of proportionality.

Experience tells us that the temperature rise is also a function of the residence time but an exact relationship has not been defined.

Experience also tells us that the degree of mixing or the mixing efficiency is related to the total shear

taking place in the metering section.

We are now in a position to study the effects of scaling up the essential screw dimensions on extruder performance. Consider the following examples where the scale-up factor, x, has been assigned an arbitrary value of 2.

Example 1

D is increased by a factor x (=2)
h and N are not changed

Results

Open discharge, αN (2), increased by $x^3 = 4$
Back flow, βP, (6) unchanged
Net output rate, Q_n (7), increased by $x^3 = 4$
Residence time, t (8), unchanged
Shear rate, γ (9), increased by $x = 2$
Total shear, S (10), increased by $x = 2$
Cut-off pressure, Pc (11), increased by $x^3 = 4$

By doubling the diameter without changing the channel depth or screw speed, the output rate would be quadrupled. Mixing would be improved as a result of the increase in the total shear but the material would overheat as a result of the increase in shear rate.

Example 2

Same as Example 1 except we will now reduce the screw speed in the larger machine by a factor 1/x to maintain the original rate of shear.

Results

Open discharge now increased by $x = 2$
Back flow still unchanged
Net output rate increased by $x = 2$
Residence time now increased by $x = 2$
Shear rate now unchanged
Total shear still increased by $x = 2$
Cut-off pressure now increased by $x = 2$

By doubling the diameter and reducing the screw speed to one half of the value for the smaller machine, the net output rate would only be doubled. Mixing would still be improved as a result of the increase in total shear but the material would now tend to overheat as a result of the increase in residence time and total shear.

Example 3

D and h both increased by the factor x (=2)
N is not changed

Results

Open discharge increased by $x^3 = 8$
Back flow increased by $x^3 = 8$
Net output increased by $x^3 = 8$
Residence time unchanged
Shear rate unchanged
Total shear unchanged
Cut-off pressure unchanged

At first glance this might appear to be an ideal situation. The output rate has been increased by a factor of eight while the residence time, shear rate and total shear are not changed. Further examination shows that the rate versus pressure curve is now very steep, however, (open discharge increased by a factor of 8, cut-off pressure unchanged). This system would be very sensitive to changes in pressure, both with respect to output rate and frictional heat development. It is probable that the larger diameter screw would not develop enough frictional heat, except at high pressures and low output rates, and that the original assumption of adequate melting capacity in the feed and transition sections would not be met at the 8-fold rate of throughput.

Many other combinations of barrel diameter, channel depth and screw speed could be tried and the effects evaluated by means of equations 2, 6, 7, 8, 9, 10 and 11. Most give results which are not ideal in one respect or another. A compromise situation which has been employed with considerable ssuccess by extruder manufacturers is illustrated in Example 4.

Example 4

D increased by x (= 2)
h increased by $x^{1/2}$ (= 1.414)
N decreased by $x^{1/2}$ (= 1.414)

Results

Open discharge increased by $x^2 = 4$
Back flow increased by $x^{2/3} = 2.83$
Net output rate increased by $x^2 = 4$
Residence time increased by $x^{1/2} = 1.414$
Shear rate unchanged
Total shear increased by $x^{1/2} = 1.414$
Cut-off pressure increased by $x^{1/2} = 1.414$

This gives a four-fold increase in output rate, improved mixing as a result of increased total shear and a slight increase in temperature resulting from the increase in residence time.

Scale-up from a 2.0" diameter machine on this basis is illustrated in Table I where satisfactory operation was assumed at a channel depth of 0.085" in a 4 turn metering section and a screw speed of 200 RPM. Output rates are calculated for low density polyethylene.

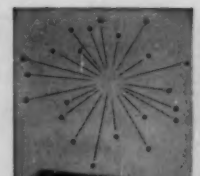
Table I. Scale-Up by Method of Example 4

Barrel Dia. Inches	Scale-Up Factor x	Channel Depth Inches	Screw Speed RPm	Shear Rate Sec.$^{-1}$	Res. Time Sec.	Open Discharge αN lbs./hr.	Net Output $2/3\alpha N$ lbs./hr.
2.0	1.0	.085	200	246	3.60	150	100
2.5	1.25	.095	179	246	4.02	234	156
3.5	1.75	.112	151	246	4.76	460	307
4.5	2.25	.128	133	246	5.40	755	504
6.0	3.0	.147	116	246	6.20	1350	900
8.0	4.0	.170	100	246	7.20	2400	1600

Rates between those of the last two columns of Table I would be expected in commercial operation of equipment of the various sizes at the indicated screw speeds. However, those screw speeds are slightly higher than normally employed in present day practice.

(1) "Extruder Scale-Up Theory and Experiments", J. F. Carley and J. M. McKelvey, Ind. Eng. Chem. 45, 5, 985 (1953)

edited by **B. H. Maddock**
Union Carbide Plastics Co.



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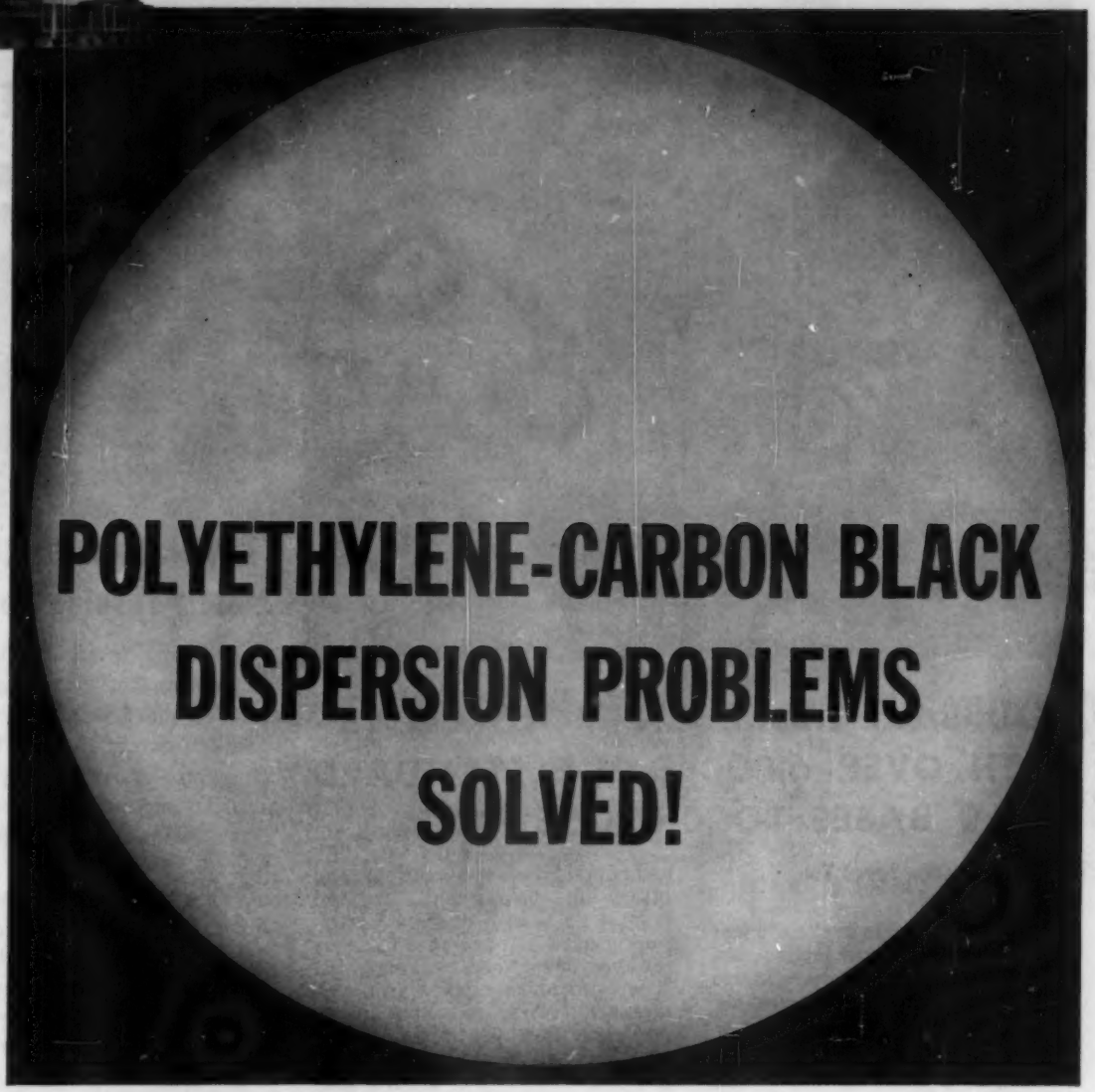

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59-A

ERNEST J. CSASZAR
NEWARK DIE COMPANY, INC.

Moldmaking

Special Considerations in Injection Mold Design

Factors to consider: Balancing, Cooling, Automation

This particular discussion is not intended to even begin to cover the field of injection mold design. However, there are certain special items that deserve to be high-lighted because of their effect on molder-moldmaker relationships.

In the September SPE Journal in the definition of a moldmaker, we referred to one who has specific knowledge, among other things, of mold techniques, so far as these elements are related to mold construction. It would be indeed difficult *not* to relate mold design with molding technique. Let us not at this time, confuse our thinking with the degree of responsibility a moldmaker would have in providing the design for a mold regarding factors of molding technique. This is another subject with many moot aspects. Perhaps we can at least say that, in order to discuss and jointly agree on a specific mold design, the moldmaker has sufficient knowledge of molding techniques to understand the reasons for special elements of design.

Aside from mechanical function, and adherence to dimension, it is sometimes necessary to perform adjustments to an injection mold before it is put on its most efficient productive cycle. This is more specifically apparent where we strive to reach the highest degree of automation possible.

The previous paragraphs are in explanation to those who might wonder why, in a moldmaking column, such items as mold balancing, cooling, gating, etc., are discussed. Since the moldmaker is often asked to make these adjustments, he is naturally concerned with the reasoning behind them.

Balancing

We have many opinions on whether or not a runner system should be balanced. Each opinion is usually backed by actual past experience on a specific item. Perhaps this is the reason for the amount of disagreements that occur. It is not easy to establish a general rule from two opposite opinions. The compromise suits neither one of them. In other words, each situation must be settled on its own environment. The shape and size of the part, the press the mold is run on, and the material used all affect the flow of material into the cavity.

The best answer to this, then, is careful consideration of all these elements *before* the mold is constructed. Opinions before mold construction can almost always be considered constructive, *after* mold construction they are little better than "Monday Morning Quarterbacking".

Cooling

The problems of adjustment relative to mold cooling perhaps can be handled in a similar way. In this case however we have some advantages. We can over design for cooling capacity and then by merely adjusting water temperature we can use only that portion of the cooling capacity that we need for the best cycle. This approach is the safest and perhaps the best. Its disadvantages in the possible extra cost for cooling capacity that might not be used. However, we are more and more using the term of "temperature control" rather than "mold cooling". One cannot have control unless there is capacity beyond what is being used. With this point of view, designing slightly over capacity would be then the normal procedure and the adjustments would be "built-in" rather than becoming an added expenditure later on.

Automation

In striving for full automation, every function molding and mold function becomes a critical factor of operation. Even a relatively unimportant element like a tiny tail on the sprue can upset our automatic operation. Usually, our greatest stumbling block towards fully automatic operation is not the part itself, but the runner system. Normal design thoughts take us carefully thru accommodating the part. However we do not consider additional cycle time to cure the runner for its best ejection condition. When we later allow for this we sometimes find ourselves beyond economical cycles regarding the piece part molding cost.

Perhaps a good solution to this would be the construction of a separate K/O mechanism to take care of the runner system, independent of the mold proper. As part of the press, this mechanism could be more elaborate because its cost could be absorbed by a number of different molds. With its own timing features, the functions of the mold could be specifically directed to the part to be molded, while the runner ejection is being handled separately.

No doubt some of the above statements leave room for comment. They were intended to. Please let us have your comments. We would like very much to include your thinking in subsequent articles.

—■—

edited by **Ernest J. Csaszar,**
Newark Die Company

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Buy a new machine or modify the old one? Here are some factors to help you decide

Molding Cycles

Cycle Improvement By Machine Modification

MILTON A. SANDERS, PRESIDENT
PRECISION MOLDING INCORPORATED
STAMFORD, CONNECTICUT

Today's injection molding presses are as different from their forerunners as todays jet planes are from the first Wright model. Although only thirty years have elapsed since the first experimental models were tried, even the change in basic principle of operation is great. The fundamental reason for evolution of the modern machine is, of course, the need for high speed production and greater versatility of operation.

In spite of all of the improvements, the need still is as great as in the past for individual modifications to meet the ever changing material and product requirements. The molder who recognizes the need and meets it squarely, progresses with the industry; the others fall behind and eventually disappear.

Who Makes the Modification?

The responsibility for development and improvement of machines theoretically lies with the machine manufacturer. Actually no one group is truly the sole center of responsibility. Usually the engineering staff of the machine manufacturer is the best qualified to accomplish the development and improvement but the idea and incentive must come from the molder's needs. Again the molder is not alone because his needs stem from his customers' product and material specifications, and these bring in both the material manufacturer and the mold builder. The cooperation of all parties in this project of modification is an absolute necessity.

If we analyze the reasons behind the ever changing appearance of injection machines, we find one which appears to be at the top of the list—the need for faster and more efficient operating cycles. It is almost with disbelief that we read the specification list of modern machines and see over 1000 dry cycles per hour as a routine rating. Material poundage output is another remarkable improvement and here too the need for speed and efficiency was the reason for the change.

The second most important reason is the demand for improved quality. This need calls for constant improvement in the control and stability of the machine as well as its ability to accommodate the increasing complexity of today's molds and materials. Temperature control has gone from the simple on-off type to the modern electronic power input control or stepless type of unit. The placement and number of thermocouples has been given proper attention and even the configuration of heat supply has been studied and applied. Hydraulic systems, electrical controls, feed mechanisms, nozzle adaptations—all of these features are modifications demanded by the needs of the consumer of plastics and translated into actuality by the teams of companies that make up the industry.

Classifying Your Machine

Now, how do these changes affect the operating cycles? And, how do these changes come about? First, it is necessary for the molder to take a totally different attitude toward his machine than he has in the past. He must regard it as nothing more than a tool, and, just as he is willing to correct, alter, or in any way make a change in a tool or mold, he must be equally willing to make a change in his machine. To determine the effect produced by any specific change in the machine, let us first classify the major systems in the machine:

1. Mechanical, consisting of frame, tie rods, platens, toggles, and accessory switch cams, latches, etc.
2. Hydraulic, consisting of pump, valves, cylinders, and tank.
3. Electrical, consisting of motor, relays, switches, timers, and in some cases, vacuum tubes with related electronic components.
4. Plasticating, consisting of feed mechanism, heating cylinder, and temperature controls.

The mechanical system provides the mounting for the mold and for the rest of the systems. It may also provide, in the case of toggles, the means for transfer of clamping force from the hydraulic system. Basically, the changes in the mechanical system provide only the convenience for changes in the other systems.

The hydraulic system provides very fertile ground for cycle improvement. Starting at the source of power, the pump determines the speed of closing of the press as well as the speed of injection. Increasing the size of the pump or adding an auxiliary pump can obviously increase the speed. One

Molding Cycles

limitation to this is the valving whose size may limit the volume of oil per minute carried by the system. Where an increase in the pumping capacity cannot be conveniently accomplished, pre-fill by gravity or vacuum systems can also be employed to increase speed. The use of a small jack ram in the clamping cylinder with its accompanying pre-fill can increase the speed of clamping sufficiently to pay for its installation in a very short time. A recent innovation in one of the well known full-hydraulic machines, a pre-loaded pre-fill tank, produces a phenomenally fast clamping motion. In many of the older machines, the oil contained in the rod end of the cylinder is returned directly to tank when the piston moves forward, such as in the mold closing stroke or the injection forward stroke. The volume of oil required at the head end of the cylinder must then be provided by the pump. The capacity of the pump thus limits the speed of the piston. If, however, the oil in the rod end is initially directed to the head end it will provide additional volume for filling the head end. Since this can be done only during the free travel of the piston when there is very low pressure, a valve known as a sequence valve is provided to direct the flow to tank when the pressure passes a predetermined limit.

The Multiple Approach

Through the use of combined modifications, that is, a change in the hydraulic system accompanied by a change in the electrical system, many improvements can be made. First, the use of a pre-pack and pre-positioning control cannot only remove wasted seconds from the injection time but it can increase the capacity of the injection stroke. The dual ratings of present day machines comes from the use of the pre-pack system. Second, safety in the form of a low-pressure closing attachment can be incorporated by the simple addition of a relief valve, a two-way or three-way valve, a limit switch, and a micrometer head. The elimination of crushed cavities and cores through double shots more than offsets the cost of the safety device. Third, quality can be benefited by the installation of multiple pressure controls for injection. Through this technique, the holding or dwell pressure is reduced, thus minimizing the tendency to pack the mold. Many more modifications can be made calling for both hydraulic and electrical alterations, each serving the purpose of gaining better performance from the machine.

Many molders hesitate when a decision must be made regarding the purchase of a new machine. The question that always arises is whether the higher speed and higher efficiency of the new machine can justify the expenditure. The simplest way short of a direct test on the new machine is through the addition of a single feature of the new machine to one of the molder's older machines. Where this is possible and practicable the molder can then determine by actual test and usually at small expense whether the claim made by the machinery manufacturer is realistic or exaggerated. Very often the molder modifies the best of his older machines and replaces those that are in need of major overhaul with the newer units.

The aim of the machine manufacturer is to produce a unit that will meet the greatest number of needs at a price that will attract the greatest number of customers. Obviously his machine must be versatile but at the same time it cannot include every feature needed without being exorbitant in price. It is therefore the responsibility of the molder to determine the features which he needs most for his field of activity and to have them incorporated in the machine at the time of purchase. As a typical case, the closure molders have need for hydraulic power take-off to drive the unscrewing mechanisms of their molds. They also require for some of their molds a stroke interruption for unscrewing. Many molders require a separate hydraulic knock-out; others need auxiliary cylinders for core-pull or similar devices. All of these variations from the standard machine serve the purpose of improving the overall efficiency of the operation.

The increasing use of hot-runner, multiple nozzle, and manifold-type molds has created a need for a fresh look at this question of machine features. Perhaps the molder and the machine manufacturer, in search of guidance, should look to the machine tool builder whose long experience has taught him to produce a basic unit to which can be added literally hundreds of attachments, each specific to a need. These attachments make virtually unnecessary any individual modifications by the user and provide for the speed and efficiency needed in his application.

To summarize, the need for improvement is always existent; whether that improvement as applied to operating cycles can be best accomplished by machine modification is yet to be determined. The very minimum conclusion is that it can be accomplished.

—■—

edited by **L. Paggi,**
E. I. du Pont de Nemours & Co., Inc.

1 PROTECTIVE FACE for picture tube housing is a one-piece injection molding of Tenite Butyrate plastic. Dark strip around edge is a "frame effect" created by painting the inside border. Molded for Philco by Buffalo Molded Plastics, Inc., Erie, Pa.

Tenite Butyrate has two jobs in new Philco TV sets

2 DECORATIVE TRIM STRIP that conceals the joint between Butyrate face plate and rear shell of tube housing is an extrusion of Tenite Butyrate. Strip is extruded with an aluminum foil insert to simulate a metal molding. Trim strip, post-formed to conform to shape of housing, is supplied by Anchor Plastics Co., Inc., Long Island City, N.Y.

Philco takes the picture tube out of the chassis ...protects it with a face of tough Butyrate plastic

The new line of Philco Predicta TV sets is another example of how Tenite Butyrate plastic can be used to improve the design and sales appeal of products.

Thanks to the toughest "face" on TV—a one-piece molding of clear Tenite Butyrate, tinted to minimize glare—Philco now features a picture tube that is dramatically set apart from the chassis.

Although many factors contributed to the choice of Butyrate here, the basic consideration was its inherent toughness, since a separated picture tube would be exposed to extra hazards.

In Butyrate, Philco engineers found a material with all the toughness and impact resistance they needed. Moreover, this Eastman plastic also satisfied the other requirements involved... light weight... optical clarity... resilience... easy moldability... high dielectric strength.

Incidentally, the color that imparts an eye-easing tint to the face is part of the plastic itself. Philco designers were able to specify the color desired, and Tenite molding compound was supplied to the molder in an exact match. Result: the tinting color is an integral part of the face, not merely a coating that might wear, chip or flake off.

If you are designing or redesigning a product, consider Tenite Butyrate whenever you need a truly tough plastic. Easy to mold, extrude or vacuum-form, Tenite Butyrate is available in clear and colored transparents, translucents, opaques, metallics, and variegations to match your specifications. For more information, write EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENNESSEE.

TENITE
BUTYRATE
an Eastman plastic

Committee Reports

SPE's Committees–Growth Ingredient for Professional Development

SPE's various committees provide a vehicle for increasing the stature of both individual members and of the plastics engineering profession

The objective of SPE is to promote scientific and engineering knowledge relating to plastics. How well the objective is achieved depends upon each and every member of SPE. In turn, the effectiveness of our members in achieving the objective depends upon the operational framework or vehicle provided them. Such a vehicle is SPE's committee system. Each year, the President appoints, with Council approval, Chairman of standing committees. Those committees, along with their Administrators and Chairmen are listed below. It is hoped that by reading this month's feature, members will become more familiar with the various committees and with their objectives. And when asked to serve on any one of those committees, we hope our members will gladly bring their creative ability and broad knowledge to bear on problems related to the advancement of the profession.

TECHNICAL VOLUMES

Administrator – FRANK A. MARTIN (Akron)
Chairman – HIRAM MCCANN (New York)
Objective – Implement the objectives of the Society to disseminate technical information relating to plastics, by sponsoring the preparation and publication of books in this field.

MEETINGS

Administrator – JOHN DELMONTE (Southern Calif.)
Chairman – JOSEPH B. SCHMITT (Pittsburgh)
Objective – Establishes and maintains policies necessary to conduct technical meetings in order to achieve the objective of the Society.

PUBLIC RELATIONS

Administrator – HAIMAN S. NATHAN (Buffalo)
Chairman – LUCIEN R. GREIF (New York)
Objective – Devises and executes policies on publicity and other means of achieving favorable public relations.

EDUCATION

Administrator – JULES W. LINDAU, III (Southern)
Chairman – CHARLES C. WINDING, (Rochester)
Objective – Finds ways to establish and improve technical and scientific courses relating to plastics, and to encourage educational institutions to maintain high standards of technical education.

SECTIONS

Administrator – GEORGE W. MARTIN (Western New England)
Chairman – G. P. HUMPHREY (New York)
Objective – Devises and executes ways and means to establish and maintain intercommunication of Sections, and uniform policies of their operation.

CONSTITUTION AND BY-LAWS

Administrator – HAIMAN S. NATHAN (Buffalo)
Chairman – ARTHUR W. LOGOZZO (Western New England)
Objective – Reviews and makes recommendations concerning all proposed amendments to the Constitution, By-Laws, Rules, or Manuals of Procedure, prior to their final adoption.

PUBLICATIONS

Administrator – FRANK A. MARTIN (Akron)
Chairman – EUGENE C. QUEAR (Central Indiana)
Objective – Has charge of all publications of the Society. With Council approval, it establishes and maintains specific policies necessary to carry out the Societies objective pertaining to national publications.

FINANCE

Administrator – HAIMAN S. NATHAN (Buffalo)
Chairman – HAIMAN S. NATHAN (Buffalo)
Objective – Supervises financial affairs of the Society. Makes recommendations on investments and unusual expenditures. Has financial records of the Society audited. Submits a budget for the next fiscal year.

NEW SECTION DEVELOPMENT

Administrator – GEORGE W. MARTIN (Western New England)
Chairman – OSCAR B. YORKER (Rocky Mountain)
Objective – Encourages and assists in the formation of and development of Sections in areas where need can be demonstrated.

CREDENTIALS

Administrator – GEORGE W. MARTIN (Western New England)
Chairman – DONALD W. BIKLEN (Newark)
Objective – This committee devises and executes uniform policies and practices concerning the appraisal of the qualifications of applicants for membership in the Society.

ELECTION INSPECTORS

Administrator – HAIMAN S. NATHAN (Buffalo)
Chairman – EDWARD L. LARKIN (New York)
Objective – Committee consists of three members, each affiliated with a different section. Duties are prescribed by the President or Council.

INTER-SOCIETY

Administrator – JULES W. LINDAU, III (Southern)
Chairman – JEROME L. FORMO (Upper Midwest)
Objective – Exchange of information on common problems.

TECHNICAL INFORMATION

Administrator – FRANK L. REYNOLDS (Binghamton)
Chairman – W. O. BRACKEN (Philadelphia)
Objective – To answer questions of a technical nature from either members or non-members.

MEMBERSHIP

Administrator – GEORGE W. MARTIN (Western New England)
Chairman – JAMES R. LAMPMAN (Central New York)
Objective – To find ways and means of increasing the membership of the Society. It cooperates with the New Section Development Committee and the Section Membership Committees.

A Shining Example

As we were going to press, the following information was received from James E. Parkhill, Chairman of the Ontario Section's Education Committee. We cite this as only one example of the way committees can accomplish significant results.

No one will learn all he needs to know or become all he wishes to be merely by reading volumes of the SPE's Plastics Engineering series or by attending SPE's sponsored courses on Plastics Technology. But he will have a better chance to learn and to succeed than the man who does not read or study.

In Canada today, as almost everywhere, plastics is one of our most rapidly growing industries. In the Toronto to Montreal area there are hundreds of companies engaged in molding plastic products or in manufacturing raw materials and equipment.

Because the industry has grown so rapidly and has become specialized in each field, it is increasingly difficult for the businessman to see more than one or two segments of the total picture.

In an effort to overcome the problem, a new extension course in plastics technology has been inaugurated by the University of Toronto in co-operation with the Ontario Section of the Society of Plastics Engineers. The complete course, which might be termed general in its scope, commenced October 6th and will last for two years. It has been designed to give both a comprehensive and an intensive background in plastics to those now actively working in the industry. It is not intended to produce trained plastics engineers; its purpose rather, is to give a broader understanding of the nature and sources of their profession to those already working in the plastics field.

Enlistment for the course to date, indicates an attendance of over one hundred. Because of this favorable response, consideration is being given to the development of a national course that could be given anywhere in Canada. This might be supplemented by a written or correspondence course for people across Canada where the industry is not as concentrated as it is in Toronto or Montreal.

Tribute for the accomplishment of this course should be paid to many. The SPE Educational Committee has been rewarded by the satisfactory completion of a Canadian first in the field of education. The industry survey conducted by Barney Kellam is worthy of special recognition. Acknowledgments are due to many companies who most graciously supplied lecturers.

This new study course in plastics will have lasting benefits to the whole Canadian Plastics Industry.

. . . as we go to press!

SPE's NEW NATIONAL OFFICERS for 1960

Elections were held October 26, 1959 at National Council Meeting, Commodore Hotel, New York, N. Y.

The new Officers do not take office until the end of the Annual Business Session, January 13, 1960. In the meantime they will be getting their committees organized.

GEORGE W. MARTIN, President

MR. MARTIN

is President and General Manager of Holyoke Plastics Corp., Holyoke, Mass. He was first Vice President of SPE during 1959 and National Secretary during 1958. Mr. Martin is a member of the Western New England Section and is a past president of that Section.

FRANK W. REYNOLDS,
1st. Vice President

MR. REYNOLDS

was SPE's National Secretary during 1959. He is Manager of International Business Machine Corporation's Plastics Laboratory, Endicott, New York.

MR. NATHAN

was National Treasurer in 1959, Vice President in 1957 and Treasurer in 1956. He was Chairman of the Finance Committee 1956-1959. Mr. Nathan is a 1935 Chemical Engineering graduate of Cornell University.

MR. SCHMITT

was a National Councilman and Chairman of the Meetings Committee during 1959. He is Polystyrene Product Manager at the Plastics Division of Koppers Co., Inc. in Pittsburgh, and a 1942 graduate in Metallurgy of the Missouri School of Mines.

MR. LAMPMAN

is a graduate in science of Michigan State University (1942). He was a National Councilman (1959) and Chairman of the Membership Committee. Mr. Lampman is Manager—Organic Chemical Engineering, Materials and Process Laboratory, General Electric Co., Syracuse, New York.

HAIMAN S. NATHAN,
2nd. Vice President

JOSEPH B. SCHMITT,
Treasurer

JAMES R. LAMPMAN,
Secretary

Technical Meetings Calendar

16TH ANTEC

ANNUAL TECHNICAL CONFERENCE—January 12-15, 1960, The Conrad Hilton, Chicago, Ill. Sponsored by the Chicago Section. For more information, contact General Chairman Franklin L. Fine, Rohm & Haas Co., 5750 W. Jarvis Ave., Chicago 31, Ill. Request for papers on page 275 of the April SPE Journal.

1959 RETECS

Washington, D. C. Sponsored by the Baltimore-Washington Section. For information write to Chairman Myron G. DeFries, Atlantic Research Corp., Alexandria, Va.

Offers of papers in the technical area of each Regional Technical Conference are solicited by each sponsoring Section. Please submit offers and abstracts to Section President indicated below for each RETEC

1960 RETECS

PLASTICS IN PETROLEUM AND PETROCHEMICAL INDUSTRIES—April 28, North Texas

VINYL PLASTICS—June, Eastern New England

PLASTICS IN BUSINESS MACHINERY—September, Binghamton

TOOLING FOR THE PLASTIC INDUSTRY—October 19, New York

BLOW MOLDING—November, Newark

Please send offers with abstracts to the President of the sponsoring Section. President of sponsoring sections are:

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Section News

Bridgeport, Conn.

Amino Resin Molding Materials

KENNETH G. CLARKE

President, Bill Coughlin of Naugatuck Chemical Company officially opened the 1959-60 season of the Connecticut Chapter at the Hotel Barnum in Bridgeport on Friday, September 11.

Program Chairman, Harlan Fisher of Watertown Manufacturing Company has planned a really diversified program for this year, and to prove it, he arranged as first topic for discussion "Molding Techniques for Amino Resin–Wood Flour Filled Compounds", quite a shift from the thermoplastic–injection molding topics which have predominated in past sessions.

As guest speaker for the evening, Mr. L. C. Pounds of American Cyanamid, Wallingford Development Laboratory, very effectively described the products, manufacturing techniques, and economics of this new family of materials. Mr. Pounds pointed out that the recent revolution in school furniture design has stimulated development of this process. He also discussed the limitations of this technique regarding geometry and appearance, and topped off his story with some very tasty examples of the profits which can be made in this field.

The value of the program and a topic relatively unfamiliar to the membership was obvious from the exceptionally lively question and answer period which followed.

The American Brass Country Club in Naugatuck provided the location for the next meeting on October 9.

Mr. Robert D. Sackett of Hartig Extruder Company discussed "Latest Trends in Extrusion".

Binghamton

Foams in Construction

LEO J. PRANITIS

The first Binghamton Section meeting of the 1959-60 season got underway at the Vestal Steak House on Thursday, September 24th. Thirty-eight members and guests heard Robert N. Kennedy speak on the topic "PLASTIC FOAMS–FUTURE TRENDS IN CONSTRUCTION".

Mr. Kennedy is Section Head of the Expanded Plastics Section of Plastics Technical Service of the Dow Chemical Company, Midland, Michigan. He supplemented his presentation with several slides to illustrate the various uses of expanded plastic products.

Section President L. N. Chellis announced to the group that the Binghamton Section had made its bid for and SPE RETEC to be held in the early fall of 1960. Its theme to be: "Plastics in Business Machines".

The next meeting will be held at the Sheraton Inn on October 22, and feature Mr. W. A. Kelley of Monsanto and the subject: "LATEST DEVELOPMENTS IN THERMOFORMING MASS PRODUCTION TECHNIQUES"

Golden Gate

Tour of Reichhold Chemicals, Inc.

THEO. V. MALIANNI

With 69 members and guests in attendance, GOLDEN GATE'S September dinner meeting was held at the International Inn adjacent to the San Francisco International Airport. A short and limited business meeting was presided over by President Jim Turner who then turned the meeting over to Jim Smith of Reichhold Chemicals. Jim then introduced Bob Reece, Vice President of Pacific Coast Operations, who, after giving a brief history of Reichhold, then narrated a half hour film entitled "A New World of Chemistry, the Story of Synthetic Resins".

At the conclusion of the film, the group then proceeded to the Reichhold plant where the large group was broken up into smaller groups and escorted through the operating plant. Guides showed and explained the various processes for making the alkyd resins which are used in paints and enamels; the urea formaldehydes which are used in cloth impregnations; the urea and melamines which are employed to add strength to cloth and paper; the phenolics which are used for their adhesive qualities, strength, and resistance to acids, and molds for metal castings; and the polyesters used as an actual material of construction.

Central Ohio

Nylon Discussed

RICHARD B. SHARPE

The annual ladies night meeting was held Tuesday, September 15th, at Ricardo's Restaurant, where a delicious meal, interesting program, and informal get-together were thoroughly enjoyed by the attending 50 members, guests, and wives.

Incoming president, Bill Rackett, introduced the new officers for the coming year and announced that the Extrusion Workshop which the Central Ohio section is sponsoring will be held on October 20th and 21st at The Ohio State University. Details for this meeting are being handled by Chairman Bob Zimmerman.

The evening's program was presented by Mr. Bill Wall, a plastics consultant for E. I. duPont Company, Wilmington, Delaware. His very interesting and enlightening talk covered the origin, development, and multi-uses of nylon. With the aid of numerous items made from nylon, he showed how this material is making a significant contribution to the agricultural, sporting goods, railroad, oil, gas, and many other industries. He emphasized points in his talk with numerous tricks he had acquired in his hobby of being an amateur magician.

Detroit

Large Turnout at Annual Golf Outing

FRANK S. MARRA

A fine turnout of about 100 members and guests attended the Annual Golf Outing on September 11th at Oakland Hills Country Club to kick-off the 1959-60 season. Jack McPherson and Leo Fleming shared the honors for the coveted Silver Bowl Trophy with identical low scores of 83 for the three-time National Open Tournament course. Leo Fleming also won the longest drive contest and Bruce Bartsch was "closest to the pin".

Television sportscaster "Bud" Lynch along with Marty Pavelich and Red Kelly of the Detroit Red Wings hockey team added to the after-dinner festivities. Co-chairmen John Burleigh and Iver Freeman received a well deserved pat on the back from the entire membership for a fine affair.

Kentuckiana

Decorating of Plastics

R. O. CARHART

The first meeting of the fall season was held Wednesday evening, September 16, 1959 at Bill Boland's Dining Room. Thirty two members and guests were in attendance. President Ray Eshenaur welcomed all and briefly outlined what promises to be a very interesting program for the coming year. On October 21, Mobay Chem. Co. will discuss "Polyurethanes" followed on November 18 by Dow Chem. Co.'s presentation of "Recent Advancements in Injection Molding". On December 17, Union Carbide Plastics Co. will tell us about "Polyolefins", Polymer Process Co. will discuss "Powder Polymer Fabricating" on January 20, and on February 17, we will hear about "Polyesters" from Naugatuck Chem. Co. On March 16, Hungerford Plastics Co. will discuss "New Plastics Advancements in Europe", "Fluorinated Polymers" will be the subject presented by E. I. du Pont de Nemours on April 20, and the years activities will be brought to a close on May 18 with a discussion of "Plastics in Electronic Applications" by R.B.M. Division of Essex Wire Co.

Following reports from the committee chairman, President Eshenaur introduced Mr. Paul Carnes of Kent Plastics, Evansville, Ind., who gave a very interesting, informative and enjoyable talk on the subject "Decorating of Plastics". Mr. Carnes discussed his company's facilities and the various materials with which they work. This was followed by a short discussion of mold design and materials which are most suitable for molding of parts which are to be decorated. Also discussed were the various decorating techniques used by Kent which included silk screening, vacuum plating, plug and spray painting and hot stamping. The advantages and shortcomings of each were pointed out. Mr. Carnes' talk was well illustrated with some of the small tools used in the various processes and with many sample parts.

Miami Valley

Plastics in Building

STEPHEN D. MARCEY

The Miami Valley Section of the Society of Plastics Engineers, Incorporated held its first regular meeting of the new fiscal year at the Golden Lamb Hotel, Lebanon, Ohio on Thursday evening, September 10, 1959.

Following a short business meeting a talk entitled "More Plastics—Better Buildings" was presented by Mr. Donald Gray of Plastics Technical Service, Dow Chemical Company, Midland, Michigan. The subject was a thorough discussion of the use of plastic materials in the building industry field covering such materials as styrene foam, polyethylene, vinylidine chloride, and others. Slides were used to supplement the talk.

Milwaukee

Magic Molecules

JAMES C. ENGMAN

The Milwaukee Section held its first meeting of the 1959-60 season September 15th with thirty members present.

Joe Stewart subbed for Herb Goeder Section President and Paul West gave a report on National Council Activities. A treasurer's report preceded the Program Chairman Harold Hulterstrum's moderation of an open discussion on the fall and winter program. The movies "Magic Molecules" and "This is Color" concluded the evening.

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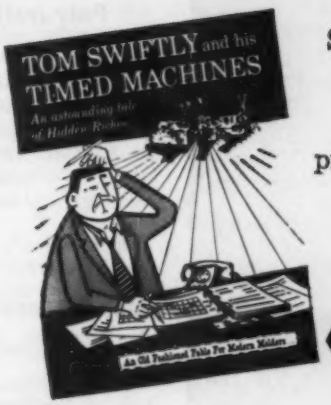

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Newark

Injection Molding vs. Vacuum Forming

DAVID SAHUD

The Newark Section resumed its program activities on September 9 at the Military Park Hotel, after a summer hiatus. The program was highlighted by a panel discussion on "Injection Molding vs. Vacuum Forming," moderated by Ernest Moslo, Moslo Machinery. The panel consisted of Robert Kostur, Comet Industries, and Frank Quimby, Grace Chemical, on vacuum forming and John Kent, Monsanto Chemical, and Edward Rowan, Parkway Plastics, on injection molding. The presentation served to enlighten the gathering on the food container industry, the techniques of vacuum forming, and the relative merits of the two techniques. In summary, injection molding was shown to be advantageous where thick containers for automatic filling equipment and good resistance to heat and pressure is desired; where a variety of designs and close tolerances are necessary; and where raw material costs are critical (the higher cost in vacuum forming being introduced by the necessity of starting with extruded sheet instead of molding powder. Vacuum forming is encroaching on the market for thin walled (less than 20 mils) containers, small scale production applications (where the cost of the mold can be written off), and in large specialties, such as refrigerator doors. The discussion was followed by a lively question and answer session with the audience.

North Texas

Polyurethane Foams

E. H. SWAZEY

The September meeting was held on Sept. 21, 1959, with William A. Kresge, of Nopco Chemical Co. the speaker. Mr. Kresge displayed several kinds of foams and demonstrated foaming in place at the meeting.

Northwestern, Pa.

Joint Meeting with ASME

JOHN J. AUGUST

The Society of Plastic Engineers, Inc. of Northwestern, Pa. held their October 22, 1959 meeting jointly with the American Society of Mechanical Engineers.

The topic was "Premier Plastics" and "Plastic Tooling" with a twenty minute sound slide presentation by Mr. Howard Henderson, Regional Sales Technician for Ren Plastics Inc. of Lansing, Michigan.

Ontario

Canadian and Indian Plastic Industry

HAROLD A. SHURE

The main problem in the Indian Plastics Industry, and India as a whole, is the acute shortage of all foreign exchange, so necessary to purchase raw materials for building and feeding basic and secondary manufacturing plants. This was the report of L. J. Shehan, Canadian General Electric Co. Ltd. Most fabricating and moulding methods are similar to those in Canada, but the quality and public demands are very different. The Indian Industry caters accordingly.

Ontario Section President John Glen introduced Professor W. G. MacElhinney of the University of Toronto, who spoke briefly on the two-year extension course "Fundamentals and Technology of Plastics" being sponsored by SPE Ontario Section and commencing October 6, 1959.

The Ontario Section meetings will be held on the third Thursday of Each month (except for the Christmas meeting this year). This change in day has been made so that meetings do not coincide with the Tuesday lectures on the Fundamentals and Technology of Plastics course at the University of Toronto, and sponsored by the Ontario Section.

Rochester

Delrin

JOHN T. BENT

Doctor Harry Cates opened the 1959-60 season by delivering an excellent paper on their new acetal resin "Delrin". Doctor Cates discussed the physical and chemical properties of Delrin, its molding properties, methods of assembly, and its fields of application. His talk was well illustrated with colored slides.

Southeastern Ohio

Plastics in Electric Motors

WILLIAM J. STRANAHAN

The Southeastern Ohio Section held its first of the fall meetings in the Zane Trace Dining room, Cambridge, Ohio. A good turnout was present at the dinner meeting that was followed by a

complete plant tour of the March Electric Co. facilities. The Business of the evening was led by Section President William J. Stranathan of Cambridge Tool and Die Co. Cambridge Ohio.

The main Speaker of the evening was introduced by John Dandalides manager of March Electric Plant. Mr. Dandalides stated that Mr. Cole is now Chief Research and Development Engineer of the Lamb Electric Co., a Division of the American Machine and Metals Corp.

Mr. Cole's topic won The Evolution of The Fractional Horsepower Electric Motor. Mr. Cole stated that the earlier cleaner Motor contained 4 1/3 pounds of raw lamination steel and carried a rating of ¼ H. P. In Comparison motors newer design contain 3¼ pounds of steel and are rated at 9/16 H.P. at 17,500 R.P.M. about 5½ times as much power per unit of weight of raw steel.

Early magnet wire insulation consisted mainly of plain baked on enamel which was usually covered with one or two layers of either cotton or silk fibers. This enamel had poor mechanical strength as compared with present day materials and was softened by the solvents of most varnishes and by heat. This expensive and bulky material had a poor space factor for winding and poor heat conducting quality. It was not until about the end of the Second World War that the present high strengthwire enamels such as polyvinyl formal Resin, Polyethylene Terephthalate, Isocyanate, Polyurethane etc. came into general use under the trade names of Formex, Formvar, Soldereze, Nyform, Nyeze and many other names. These materials have been a great boom to the motor designer as they have enabled him to put considerably more copper into his motor windings with resultant increase in power output and reduction in temperature. The development of Tetrafluoroethylene by the DuPont Company under the trade name of TEFLON has greatly increased the permissible temperature rise of motors for certain hot spot applications, this material being unaffected by temperatures up to about 600°F.

Mr. Cole also implied that the use of nylon for brush holders has also solved a problem in that part of the motor.

After this most informative talk the group enjoyed a tour of the modern motor plant in which automation has been applied where possible. Probably the most interesting operation was the high speed winding of motor stators and armatures, again plastics have been applied to speed up this operation which is conducted at a high rate of speed. A thin coating of Nylon is used in outer coating of the wire in order to give it more abrasion resistance, also at the same time adding to the surface finish, which is necessary in the high speed handling of the wire.

Southern California

Continuous Filament Winding

JOHN A. STAHMANN

On September 3rd the Rodger Young Auditorium was filled with 138 members and guests as the new season of meetings began. Special introductions of the Board of Directors were made and the summer's activities were reported upon.

Mr. W. R. Dana, the speaker of the evening, is Chief Engineer for the Amercoat Corporation. He is responsible for their engineering, development, and plant management. His firm makes a specialty of continuous filament winding.

Mr. Dana reported that filament winding was developed in 1947 under the sponsorship of the Bureau of Ordnance. The advent of high strength glass fibres and strong resins contributed greatly to the successful development of the technique. The first winding was made over a rubber bag with all glass fibre. Present methods develop higher tensile strengths by continuously impregnating the fibre with resin during winding.

For simplicity, winding methods may be divided into two categories, namely, circumferential winding and helical winding. In circumferential winding the fibre is lain on in a continuous radial motion. It is sometimes reinforced longitudinally, since most of its strength is in the one radial direction. The helical winding method moves the fibre in a spiral motion while the mandrel rotates. This gives both longitudinal and horizontal strength. The wrapping of each type of structure is designed to fulfill individual requisites.

In testing a cylindrical pressure vessel made by winding, the circumferential strength will be twice that of the longitudinal strength. Its strength to weight ratio is greater than that of aluminum.

Fibres used are generally glass, although cotton, steel, and other materials have been used. One rule-of-thumb may be used: The fewer the ends, the higher the strength. Epoxy is the most popular resin, although newer resins may become significant.

Cylinders over 14 feet long and over 14 feet in diameter have been produced by filament winding methods. Structural wound prepreg materials have found immediate and widespread interest.

St. Louis

Delrin Subject of Talk

LYLE R. DEAN

The September meeting of the St. Louis Section was held at the Prime Rib on Clayton Road, September 21, 1959. Forty members and guests were present.

Otto Wulfert, Chairman of the RETEC on "Plastics in the Shoe Industry," reported that the speakers for the program have been selected and papers have been submitted to the national office for preparing reprints. Replies to the first mailing indicate much interest and a good turn out for this RETEC is expected.

The speaker of the evening was Mr. John Lutz of the Polychemicals Department, E. I. du Pont de Nemours & Company. He talked about Du Pont's new thermoplastic, "Delrin"* acetal resin. With the use of slides, he explained how the chemical linkage of this polymer differed from most other polymers and why this linkage gave the material a high degree of strength and rigidity. He explained how the combination of physical properties of this material gave it a high fatigue endurance limit making it a good candidate for gears.

Mr. Lutz stated that market studies indicate 75% of the applications for this new thermoplastic will be in the replacement of metal parts; such as, machine brass parts, die cast zinc parts and, in some cases, stainless steel parts. Mr. Lutz had quite an impressive array of parts molded from "Delrin" acetal resin; such as, an automobile instrument housing, aerosol containers, refrigerator door handles, a fishing reel housing and many others.

Upper Midwest

Polish Plastic Industry

CHARLES M. SMITH

Following the September 21st 6:30 social hour and dinner at the President's Cafe, the first meeting of the 1959-60 season was called to order by Section President, Donald C. Brekke.

After a brief business meeting, the program was turned over to Mr. Jerome L. Formo of Minneapolis Honeywell Regulator Company who spoke on the subject "Polish Plastic Industry". Mr. Formo, past National

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President of SPE and National Councilman of the Upper Midwest Section, recently returned from a trade mission to Poland where he had an excellent opportunity to study the Polish plastic industry. He presented a very interesting talk supplemented with slides.

Mr. Formo explained that while the Polish people have worked with plastic for many years it wasn't until 1951 that the industry really became established. In the past two years the plastic toy industry has been developed and in 1958 11,000 tons of phenolic were molded. The average Polish worker has to work two weeks to pay for a pair of shoes and two months to pay for a suit. Even then he must pay cash and have a permit.

Polish people are very devoted to their work and right now are most interested in developing a better polyethylene. Regarding this type of plastic, Mr. Formo felt they are now in the development stages we were in in 1939.

Western New England

Connecticut Yankee in Russia

ARMAND G. WINFIELD

John M. DeBell, President of DeBell & Richardson, Inc. gave a stimulating and informative talk on his recent trip to Russia. As a technical expert on a million dollar extrusion installation in the Soviet Union, Mr. DeBell had unusual opportunities to meet with Russian officials and to travel "freely" about the country. He was present at the Nixon-Khruschev Debate. On overall impressions, Mr. DeBell observed that the Russians are trying internally to improve standards of living, sciences and education. Their general technology is 10 to 15 years behind ours. They are proud of their parks, apartment houses, public building . . . of their collective farms, cultural centers, theaters, schools. They are sensitive about poverty and "losing face." The government is holding the people by the same means as Hitler did—by appealing to their better instincts . . . plugging education . . . adapting skills to maximum usefulness . . . encouraging morals . . . inculcating healthy respect for work . . . upgrading raw materials.

On Research, his observations are that their research is good, ably and resolutely conducted; it is scientific. Good laboratory work is being accomplished but there is a big gap in operating technology.

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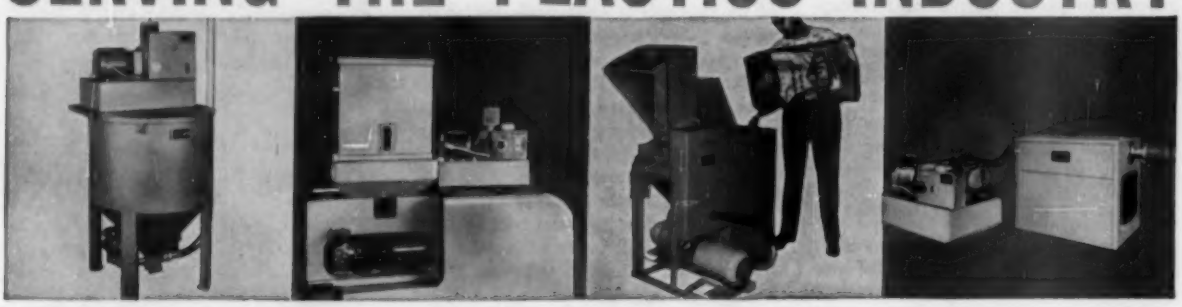

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About Members

Rudolph W. Kugler has been appointed assistant to George F. Blasius, President of Cary Chemicals Inc. His primary duties will be those of administration and planning. Mr. Kugler is a graduate of the Case Institute of Technology, Cleveland, Ohio, he holds a B.S. in chemical engineering.
Prior to his appointment to this present position, Mr. Kugler was with Courtaulds, Inc. as manager of New Product Development. He was also a sales representative with the Dow Chemical Co. in New York City and purchasing agent for the Heil Process Equipment Co. of Cleveland, Ohio. Mr. Kugler is a member of the N. Y. Section of SPE.

William J. Rainey was announced manager of the Styrene Production Control Laboratory for Foster Grant Co., Inc., Polymer Products Division. Prior to joining Foster Grant, Mr. Rainey was superintendent of the Quality Control Laboratory in the Newark, N. J., plant of the Celanese Corp. He is a member of the Newark Section of SPE. Mr. Rainey of Fanwood. N. J., received his B.S. degree from St. Peter's College, Jersey City, N. J., and his M.S. from Rutgers University.

Dr. Ben P. Rouse, Jr., has been appointed chief chemist, Tenite Development Dept., Tennessee Eastman Co., Kingsport, Tenn., division of Eastman Kodak Co. Dr. Rouse, a member of the Southern Section of SPE and Sigma Psi, holds B.S., M.S., and Ph.D. degrees in chemistry awarded by Virginia Polytechnic Institute.

David W. Towler has been appointed Western New England sales representative for Plaskon molding compounds, Plastics & Coal Chemicals Division, Allied Chemical Corp. A member of SPI and a former Director of the New England branch of SPE, Mr. Towler received his B.A. in chemisty from Brown University in 1943.

Rudolph W. Kugler

David W. Towler

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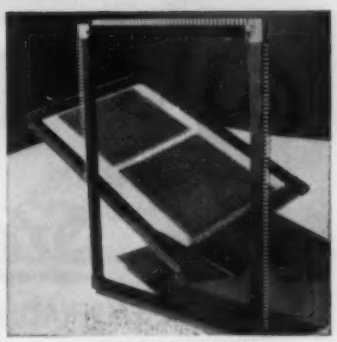

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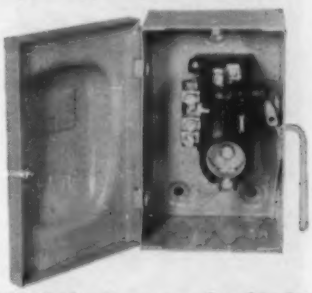

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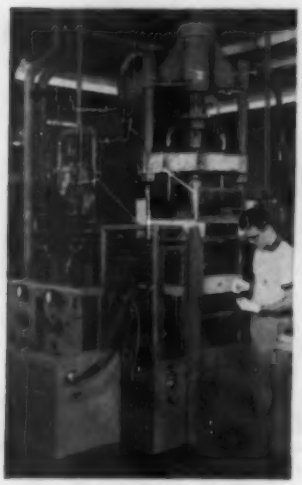

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About Members

Paul J. Wright has been named sales representative in the plastics division export sales section of Eastman Chemical Products, Inc. Mr. Wright joined Eastman as a sales trainee in 1955 and served as a sales representative in the plastics division office in Chicago. He is a University of Kentucky graduate. Mr. Wright is a member of the Chicago section.

Thomas L. Loveless has been named to head the new sales office of the plastics division of Eastman Chemical Products, Inc., in Fort Washington, Philadelphia, Pa. He is a graduate of Alabama Polytechnic Institute with a B.S. degree in Mechanical Engineering. Mr. Loveless is a member of the Newark section.

Robert L. Grinstead, head of Kayron Chemicals, Montreal, Canada, will provide technical service to Claremont Pigment Dispersion Corp.'s Canadian customers.

George E. Hulse has been appointed director of the newly formed research and development department of Chemetron Corporation's Chemical Products Div. His headquarters will be Rock Hill Laboratory, Newport, Tenn. Hulse formerly was with the U.S. Rubber Co., Hercules Powder Co., and the Spencer Chemical Co.

William H. Young, a member of the Baltimore-Washington Section has been appointed Plant Manager, Pharmaplastics, Inc., Baltimore, Md.

J. E. Brister will serve in the new position of Coordinator—Defense Materials, Union Carbide Plastics Co. Mr. Brister has been with Carbide since 1933. Since 1957, he has served as Product General Manager, Polyolefins.

Les J. Shehan has just returned to Canada after spending one year in India on behalf of the United Nations Technical Assistance Organization. He was seconded to the United Nations from Canadian General Electric Co Ltd., Cobourg, Ontario, in connection with direct technical assistance program on plastics.

Robert S. Elliott and **Roy E. Theiss,** both members of Golden Gate, and R. Ting who soon will be, have recently formed a new company to be known as Royell, Inc. Mailing address of the new company is Box 325 Station A, Palo Alto, Calif. The company offers a new distributor of raw materials to the reinforced plastic market in California.

Andrew A. Dukert has been elected a vice president of Penn-Plastics Corp., Glenside, Pa. Dukert was formerly chief engineer and assistant general manager. He is a member of the Philadelphia section of SPE.

Maurice E. Bailey was recently appointed Manager of Isocyanates Service, Buffalo, N. Y., Allied Chemical's National Aniline Division announced. Dr. Bailey will lead this technical service group and will be responsible for transmittal of technical information on polyurethanes and isocyanates. He has been with Allied Chemical since 1941. He is a graduate of Ohio Wesleyan and was awarded M.S. and Ph.D degrees from Purdue University.

KUNSTSTOFFE

Germany

MAY, 1959

Polystyrene—Past and Future—Obering H. Beck

Block, emulsion, suspension and solution polymerized styrene polymers are compared as are the new developments in steriospecific polymerization of styrene. Improved properties of high impact styrenes and ABS polymers are discussed. The importance of controlled processing conditions during molding or extrusion is emphasized.

MAY, 1959

Effect of Small Plasticizer Concentration on PVC—Dr. O. Fuchs and Dr. H. H. Frey

Much has been reported on PVC-plasticizer combinations where the plasticizer concentration is 20 to 50%. However, little has been published about plasticizer concentrations less than 15-20% because there are no improvements in brittleness shown over unplasticized PVC, and at some concentrations, in fact, an increase in brittleness is seen. A number of different plasticizers at several concentrations were studied. This indicated that the embrittlement at low concentrations was related to the solvent action of the plasticizer.

MAY, 1959

Plastics in Industrial Packaging—Ing. Fritz Reinke

A new standardized package for industrial packaging is described. It is standard in that it consists of a standard size polyester-fiberglass outer container of uniform size which contains inserts of thermoplastic film or sheeting. These inserts are specially prepared for each individual packaging job and are interchangeable so that any of them may be fitted into the outer container. Cost comparisons are made between this proposed type of package and packages of conventional construction.

MAY, 1959

Analysis of Commercial Formaldehyde by Combined Measurement of Dielectric Constant and Density—Dipl.—Chem. Friedrich Oehme

A method for determining the concentration of formaldehyde in methanol solutions is outlined. Previous methods using only the dielectric constant were useful only when a trace of methanol was present. Plotting the known values of dielectric constant and density of triangular graph paper versus concentration leads to a diagram which can then be used for determining the concentration anytime one knows the dielectric constant and density.

MAY, 1959

Measurement of Dimentional Stability at Elevated Temperatures—Dipl.—Phys. W. Gohl

The Martens Test for dimensional stability depends on the modulus of elasticity being at least 711,000 psi to yield reliable results. For this reason, the test has been adequate for thermosets but not for most thermoplastics. A test overcoming these difficulties is described using polyethylene. It consists of determining the self deformation point using a beaker molded from the test material. This new test is said to be a simplification of the ASTM D 648 heat distortion test.

MAY, 1959

Measurement of Solution Viscosity of Commercial Polyolefins—Dr. Hermann Wesslau

A method of determining the "reduced viscosity" is described and is said to be useful in determining the molecular weight of polyolefins. It is suggested that the method, which is described in some detail, be adapted as a standard specification.

MAY, 1959

Single Cavity Molds for Screw Caps, with Antechamber and Internal Gated—Dipl.—Ing. H. Gastrow

A mold construction is described whereby screw caps with no visible gate marks can be produced. The mold incorporates automatic unscrewing and is said to be versatile enough so that inserts may be changed for different sizes. The mold operates completely automatically and is ideally suited for short runs of different sizes.

MAY, 1959

Acrylics in Display and Advertising—Dr. Franz Esser

Acrylics are ideally suited for display and advertising signs. The importance of the many properties connected with this application are discussed. They are: machining, optical properties, thermoforming, model making, weathering resistance, use of dyed material, painting and silk screening, and methods of production.

Plastics Around the World

This month's column has been made possible through the contributions of these abstracters:

Alfred L. Alk (Materie Plastiche, Seleplastic)

Charles Imig (Kunststoffe)

Albert Lightbody (Practical Plastics in Australia and New Zealand)

James M. Margolis (Der Plastverabeiter)

MAY, 1959

Rheological Construction of Simple Extrusion Dies. Part II New Methods for Construction of Cross-Heads, Film Blowing Heads and Tube Dies.—Dr.—Ing. Gerhard Schenkel

Die constructions are discussed in detail which will equalize pressure to the die orifice and eliminate flow lines.

DER PLASTVERARBEITER

Germany

AUGUST, 1959

Vacuum Forming Polyethylene—Dr. G. Cramer

In recent years this process has been used more and more, especially in U.S.A. In U.S.A. in 1958, nonetheless, only about 3% (or 54,000 tons) of all thermoplastic products were vacuum formed. During the next three years this is expected to climb to 10%. The development of automatic vacuum forming has resulted in mass production of such items as ice cream containers in a way not possible by other thermoplastic molding processes.

MATERIE PLASTICHE

Italy

JULY, 1959

Dilatometry in the Study of Macromolecules—G. Lanzavecchia

The measurement of dilatancy is a simple and modest means of determining first and second order transformations in the structure of high polymers and changes brought about by chemical, thermal and mechanical means. This thorough study of the subject includes a description of the technique of measurement.

JULY, 1959

Polymethylmethacrylate in Injection Molding—I. Ronzoni, M. Mazzoni

The authors have studied the parameters of polymethylmethacrylate production and here present tables and charts, drawings and text to introduce the molder to the material. 28 literature references.

AUGUST, 1959

Plastics and Packaging at the 8th Packaging Salon—A. Osella, A. Pozzati

The 37th International Samples Fair at Padua May 29 to June 14, 195 contained a large section devoted to plastic packaging comprising exhibits of 61 producers and consumers of packaging products. Products and machines are illustrated and described in the text.

AUGUST, 1959

The Ninth National Packaging Congress—Padua

The following were papers presented: Plastic and Resinous Packages for Food and Farm Products by Dr. Luigi Manzini. The Prospects for Polyester and Polypropylene Films in Food Packaging by Ing. Sergio Antiochia and Dr. Luciano Lucchetti The Problem of Toxicity of Plastics in Food Packaging by Ing. Piero Ghersa.

AUGUST, 1959

The Use of PVC in the Insulation of High Tension Cables—P. Parrini

Presented here are the latest reports in the field of high tension and strong current insulation through the use of PVC as insulator. There are described in the text the requirements for PVC base insulators and coverings for various levels of power. Also described are comparisons between PVC insulation and impregnated papers with lead sheaths. There are 23 literature references.

AUGUST, 1959

The Co-Polymers of Maleic Anhydride—E. Ferraris

Water Soluble Resins Part I. A very broad survey article based on patents and other technical sources is presented in this series. The subjects discussed in this part are: hydrophilic copolymers, hydrophobic copolymers and maleic anhydride-styrene copolymers. There are 132 references in the bibliography.

PRACTICAL PLASTICS IN AUSTRALIA AND NEW ZEALAND

Australia

JUNE, 1959

Formula for Nylon Gears—Staff-Written

The grades of nylon to be used for gears are listed as machinable from solid rod or tube stock or injection molded. Advantages are given as noiseless transmission, wear resistance, elastic transmission, corrosion resistance and low specific gravity. Factors to be reckoned in designing gears include heat discharge, moisture content and margins, due to changes in size brought about by heat and moisture. Rules for fastening gears are also given.

—■—

Correction

Infrared Spectra and the Structure of High Polymers
September SPE Journal, pages 797-804
by
S. Krimm, University of Michigan

Figures 4 and 5 appearing on page 801 of the September Polymer Science feature were incorrectly captioned. In addition, one illustration, Figure 4 below, was inadvertently omitted from the article. Following are the correct figures and captions referred to on page 801, right hand column, under Polyvinyl Alcohol.

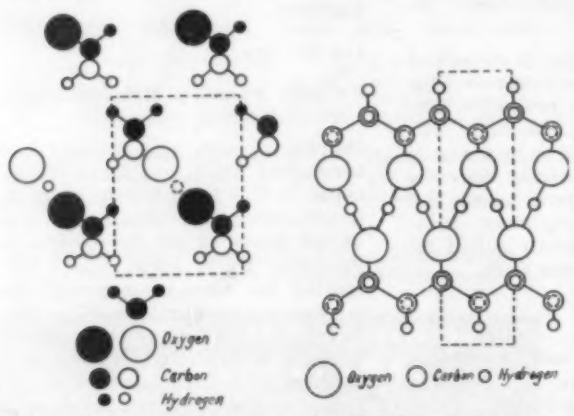
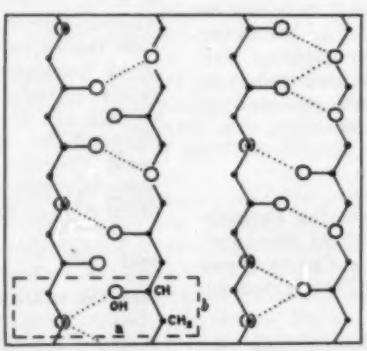
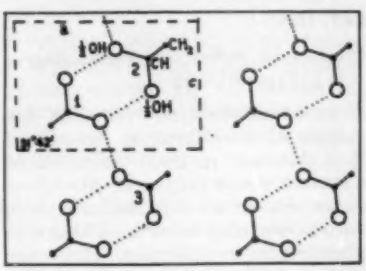


Figure 4. Mooney structure for Poly(vinyl alcohol). (Ref. 24)

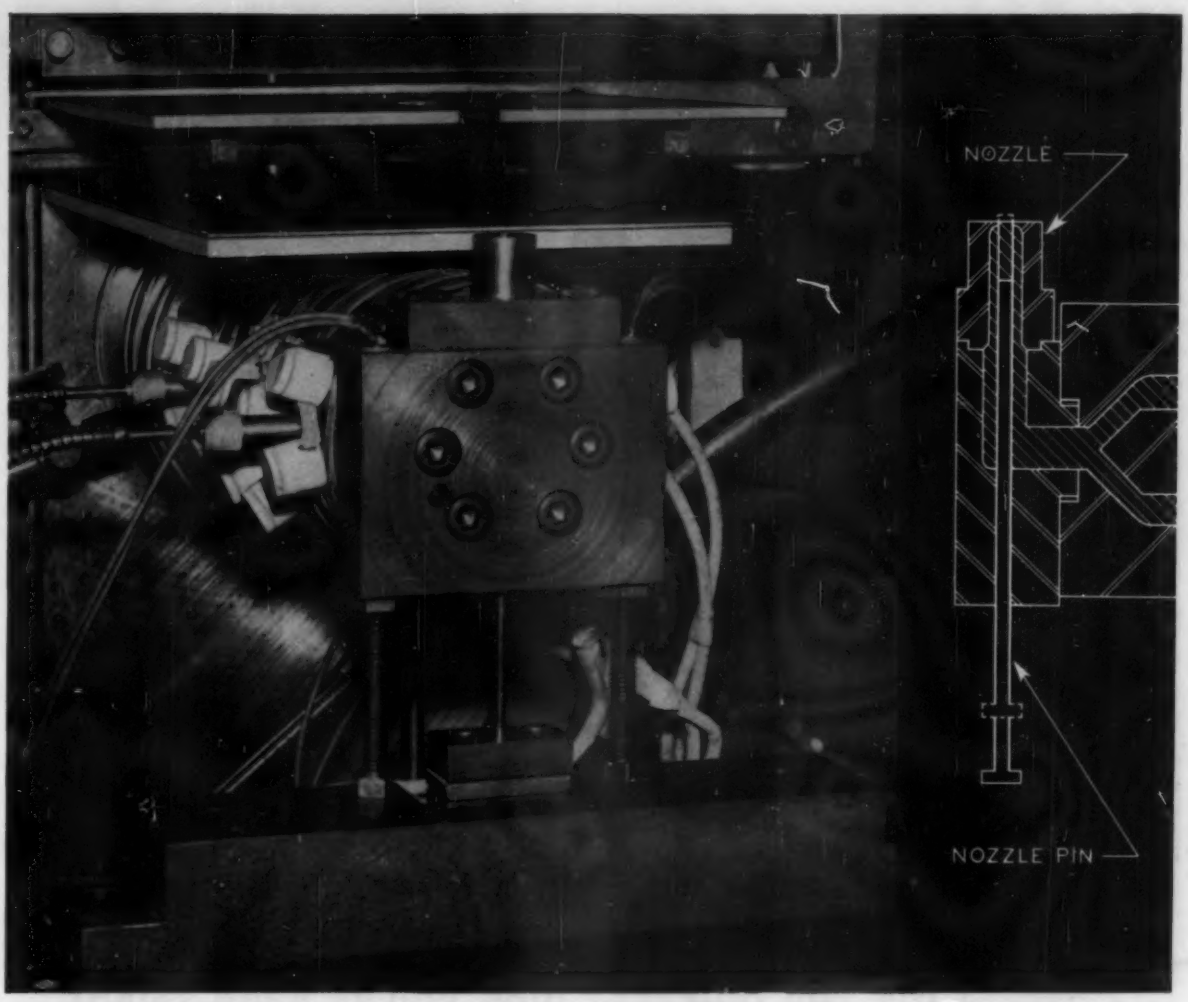


a



b

Figure 5 (a and b). Bunn structure for Poly-(vinyl alcohol). (Ref. 2)



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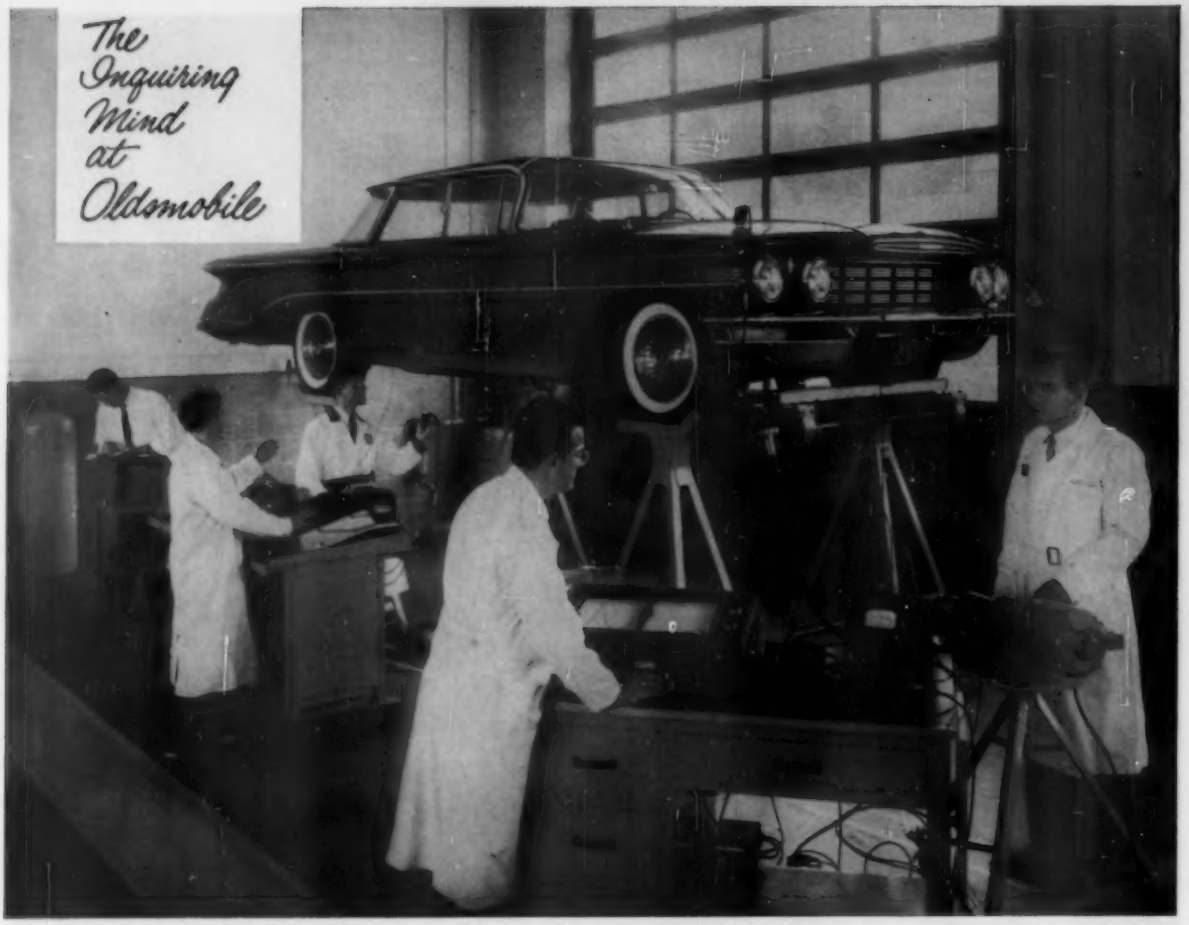

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One of the unique ways in which noise and vibration are isolated by Oldsmobile engineers is through Vibra-Tuned body mountings. These mountings—direct attaching points between the body and frame—are critical to comfort and to the life of the car. If they are not properly placed, severe road vibrations can literally shake the car apart in a few thousand miles. But, by using the most advanced electronic measuring techniques, a softer and quieter ride is achieved by placing the body mounts at the nodal points of the frame. In this way, inherent road vibrations and shocks are practically isolated from the passenger compartment.

In the "tuning" of the chassis and body, the car is subjected to severe shaking, at a frequency of 7½ to 15 cycles per second, by a mechanical oscillator to produce torsional and bending moments. By using numerous electronic pick-ups, movement of the frame and body at a given point can be determined quickly and translated into an accurate magnitude vs. frequency curve through an X-Y plotter. By a complete and thorough examination of the entire car in such a manner, it can be determined where the "dead" or nodal points are on the frame, and the body mounts can then be scientifically placed. Then, after being located, the hysteresis characteristics of the body mounts are determined to give the most satisfying ride.

These methods, and many more up-to-the-minute techniques, have enabled Oldsmobile engineers to build consistently fine quality automobiles year after year. Visit your local authorized Quality Dealer and drive a 1960 Oldsmobile. See why it's the most satisfying car you've ever known . . . *the finest the medium-price class has to offer!*

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Line speeds to 500 fpm

Widths from 24" through 120"

It pays to rely on Egan precision engineered equipment for completely packaged extrusion casting installations!

EGAN FILM CASTING UNITS include these features: highly polished, chrome-plated casting rolls with spiral baffling for even temperatures; a specially designed air-knife with an adjustable assembly for controlling "frost line" and assuring uniform film contact across full face of roll; edge trimmer assembly; trim disposal system; turret type winder with electronic drive for each winding position to provide programmed tapered tension, and web cut-off and transfer at operating speeds.

EGAN HEAVY DUTY EXTRUDERS have been tested and proven in the field! These dependable, high-capacity, low maintenance units are available in sizes from ¾" through 10". Economical ceramic heater bands provide fast heat-up time and operating economy. The overall extruder components assure closer tolerances and uniform gauge. For absolute control of heating, cooling, and excessive frictional heat, the patented "Willert Temperature Control System" may be included. Complete instrumentation is included.

EGAN DIES for cast film installations are of the manifold type with provision for die blade adjustments. Heaters are divided into separate zones with individual pyrometer type controls. The main die body, in conjunction with a specially designed 45 degree adapter, is arranged so the casting rolls can be moved close to the die orifice.

Egan **FRANK W. EGAN & COMPANY**

CABLE ADDRESS: EGANCO—SOMERVILLE (NJER)

SOMERVILLE, NEW JERSEY

Manufacturers of plastics extruders, dies, take-offs, and other accessories

REPRESENTATIVES: MEXICO, D. F.-M. H. GOTTFRIED, AVENIDA 16 DE SEPTIEMBRE; JAPAN-CHUGAI BOYEKI CO., TOKYO. **LICENSEE:** GREAT BRITAIN-BONE BROS. LTD., WEMBLEY, MIDDLESEX.

Annual Financial Statement of Society of Plastics Engineers

July 20, 1959

The Society of Plastics Engineers, Inc.
65 Prospect St.
Stamford, Conn.

Gentlemen:

I have examined the books and records of The Society of Plastics Engineers, Inc., for the period July 1, 1958 through June 30, 1959 and found them maintained in accordance with accepted accounting principles applied on a basis consistent with that of the preceding year.

While I did not make a detailed audit of the books, I did make sufficient tests and reconciliations to satisfy myself that the Statements attached reflect the financial condition of The Society as of June 30, 1959.

Respectfully submitted,
Bruce Gordon
Public Accountant

The Society of Plastics Engineers, Inc.
Statement of Assets and Liabilities
At June 30, 1959

ASSETS

Current Assets		
Cash in Checking Accounts–Schedule 1	$10,131.38	
Cash Reserves–Schedule 2	37,525.12	
Petty Cash	100.00	
Accounts Receivable–Advertisers	9,834.62	
Inventory–Books and Supplies	6,990.60	
Total Current Assets		$64,581.72
Capital Assets		
Furniture and Fixtures		1.00
Prepaid Expenses and Deposits		
Post Office Mail Deposits	599.61	
Rent Security	1,564.50	
Travel Advances	725.00	
Payment to Dougherty & Co.–per contract	15,000.00	
16th ANTEC Expenses and deposits	3,944.22	
Total Prepaid Expenses and Deposits		21,833.33
TOTAL ASSETS		86,416.05

LIABILITIES AND SURPLUS

Current Liabilities		
Accounts Payable and Accrued Expenses	9,451.28	
Rebates Payable–Sections	1,751.00	
Due from Operating Fund to Contingency Reserve	15,000.00	
16th ANTEC Registrations Received In Advance	4,925.00	
Dues Received in Advance	207.58	
Total Current Liabilities		31,334.86
Reserves		
Contingency (contra)	7,715.92	
Research (contra)	29,809.20	
Total Reserves		37,525.12
Surplus		
Balance–July 1, 1958	30,614.38	
Less: Excess Cash Transferred to Contingency Reserve	11,029.61	
Surplus Adjusted	19,584.77	
Excess Revenue	(2,028.70)	
Total Surplus		17,556.07
TOTAL LIABILITIES AND SURPLUS		$86,416.05

The Society of Plastics Engineers, Inc.
Statement of Revenues and Expenditures
For The Year Ended June 30, 1959

REVENUE	
Membership Dues	69,598.47
Membership Fees	14,941.00
ANTEC–15th	61,395.23
Miscellaneous Publications	23,634.23
Interest and Other	1,646.41
	171,215.34
Journal	
Membership Subscriptions	25,308.53
Non-Member Subscriptions	6,106.50
Advertising	93,193.77
Total Journal Income	124,608.80
TOTAL REVENUE	295,824.14

EXPENDITURES	
Staff Salaries	77,603.50
Payroll Taxes	1,761.38
Travel (Staff)	11,122.41
Transportation (Nat'l Exec. Comm. Meetings)	114.62
Accounting	800.00
Legal Fees	802.39
Journal Printing, Engraving and Art Work	47,591.50
Journal Commissions	24,256.71
Telephone and Telegraph	4,330.17
ANTEC Committee	19,585.31
15th Printing ANTEC Preprint Book	9,803.75
Rent (including light, maintenance and move)	8,730.32
Insurance	646.24
Section Rebates	34,864.75
ISO Meeting, Washington, D. C.	1,303.23
Transfer to Research Reserve	11,826.93
Transfer to Contingency Reserve	448.01
New Equipment	2,931.73
Postage	8,999.35
Office Supplies	18,135.52
Printing Miscellaneous	5,428.08
Thermoplastics Processing	5,974.95
Executive Secretary's Reserve	213.46
A.B.C. Audit	578.53
TOTAL EXPENDITURES	297,852.84
EXCESS REVENUE OR (EXPENDITURES) TRANSFERRED TO SURPLUS	(2,028.70)

Pictures from . . . .

The Cleveland RETEC

The RETEC sponsored by the Cleveland Section demonstrated the tremendous scope and variety of uses of vinyl resins

◄ SPE's membership drive gets a lift from the girls at the Cleveland RETEC.

► **While** the technical "fare" at the Cleveland RETEC was excellent, the food was enjoyed every bit as much. Head table includes (left to right) Donald R. Butler, Ned McClellan, Chuck Gillingham, Jim Jones, Robert A. Abeles, RETEC Chairman; Jack R. Pecktal, Edward L. Friedman, Cleveland Section President; W. A. Messina, T. A. Bissell, S. M. Crawford, R. L. Huber, and Bernard J. Wulf.

Book Reviews

TOXICOLOGY AND APPLIED PHARMACOLOGY

A new international Journal published by Academic Press and Edited by Frederick Coulston and Arnold J. Lehman. Vol. 1, number 1, January 1, 1959. Subscription volume 1: $13.00.

The new food additives law has attracted the attention of more plastic manufacturers and users than any previous law or press headlines, even the most dramatic ones. It is because its repercussions are very wide and involve practically everyone more or less connected with the packaging or manufacturing of foods with plastic materials. Therefore this new Journal will find many readers in the field of plastics.

Among the excellent articles published in this first issue, we will mention the paper on the use of trypan blue and skin twitch tests for measuring local tissue toxicity, by James O. Hoppe, et al. It contains a table in which the toxicity of phenol, polyethylene glycol 600 monoleate and many other compounds is evaluated by this method. A paper by Robert A. Braun and Lehman M. Lusky describes the protective properties of DCD in vanadium poisoning. As ammonium vanadate and other salts of vanadium are sometimes used in the plastics and allied industries, this article is very timely.

Evidence of the importance of this whole field is seen from the fact that the subject of the Golden Gate RETEC to be held Nov. 19, 1959 is Plastics in Packaging. Luncheon speaker for this RETEC will be McKay McKinnon, Jr., of the Food and Drug Administration.

PROCESS DYNAMICS

D. P. Campbell, John Wiley & Sons, Inc., New York, 1958, 316 pages, $10.50.

Have you, too, envisioned a plastics plant of some kind that runs itself by pushing a button? We now have many isolated segments of the industry, such as some injection molding machines that appear to be almost automatic for long stretches of time. Perhaps no other industry has more to gain by it, nor is closer to this ideal by automation than is the plastics industry. Many have succeeded in the past in making isolated units practically automatic. The time and effort spent to achieve this has been large, and the results achieved almost always have been by cut and try methods. I wonder how many of us are aware that a new realm of theory is available by which process control of a moving or dynamic system can be achieved?

Such is the substance of "Process Dynamics" by the late Dr. D. P. Campbell. The writer was told that this book "was not for the beginner" but found that the complicated steps necessary, and already put into practice by most control instrument companies, is explained in this text with such care that the minimum of preparation is necessary. It is true that a knowledge of differential equations, partials, Laplace transforms, and basic engineering would make the book move a lot faster. A determination to read it carefully, however, will reveal to the reader a significant new realm of thought that is so important to the future of all controlled processes, that the writer would like to recommend it as a "must" for the practical engineer in industry as well as the future engineer now in college. Several of the most forward looking universities have adopted this text in at least one course.

For instance for the plastics engineer, in Chapter 3 we find many of the problems of extrusion, injection, and film casting put into mathematical forms from which a good start appears to be possible to control these operations and to prevent troubles from getting out of hand. More particularly, a cast or extruded web is discussed from the standpoints of propulsion, speed regulation, tension, drift, skew, and roll-up.

This is followed by a chapter on heat transfer where most of the practical methods for solids, liquids, and gases are interpreted mathematically so that control can be designed with less ruling by the thumb.

Chapter 6 ties in much of the knowledge of the chemical engineer about chemical reactions, to fit into the same pattern of mathematical techniques used for heat transfer, etc. Other chapters fit materials handling, fluids in motion, and mass transfer into this seemingly simple overall picture which someday may take the guesswork and empirical equations out of the working tools of the chemical and other process engineers.

This book is recommended as a challenge for the forward looking plastics engineer.

Robert B. Bennett
Prof. of Chemical Engineering
University of Florida

INORGANIC FIBRES

C. Z. Carroll-Porczynski. Academic Press Inc., New York, 1958. xii + 353 pp. Illustrated, $11.00.

This volume has attempted to cover the fields of glass fibers and wool, insulating wools based on rock and slag, refractory fibers, asbestos products, metal and metallized fiber both from a manufacturing and application point of view. The nineteen chapters review in some detail the manufacturing processes involved, and brief sketches of the multitude of uses of these materials. The chapters have extensive references to publications and patents. Much information is drawn from these sources as well as the sales literature of the suppliers of these products both in England, in Canada, and in the United States.

The impression is gained from reading this book that it was several years in preparation. The information in the early chapters is less current than the later chapters. For example, the author in the chapters on glass fibers (1 through 4) refers to Glass Fibers, Inc. Not until Chapter 8, page 149 on Refractory Fibers does a foot note appear describing the merger and formation of L. O. F. Glass Fibers Co. which occurred in 1955. Further, many of the glass fabric finishes developed for reinforcing plastics during the past 3 to 4 years, namely NOL-24, A-1100 or T-31, are not mentioned.

In the chapter "Recent Developments in the Asbestos Industry", the author gives a brief description of the patents listed in the references. This is an excellent innovation and would have added materially to the value of the book if carried throughout.

The book will be an excellent summation and starting point for those interested in learning about inorganic fibers. Those experienced or with advanced knowledge in the field will find the volume of limited use.

Robert Steinman
Garan Chemical Corp.

Announcing
Three New Books
First NATEC, Shoe, and Packaging RETEC Preprints

Now Available

★ **NATEC Preprint Book**—Volume I, 1959, Los Angeles, 20 papers. $5.00 members; $7.50 non-members (See program, September SPE Journal, page 788, and Abstracts on pages 815-817).

★ **Plastics in the Shoe Industry**—St. Louis Section, 11 papers, $3.00 members, $4.50 non-members. (See program, September SPE Journal, page 820).

★ **Plastics in Packaging**—Golden Gate Section, 12 papers, $3.00 members; $4.50 non-members. (See program, October SPE Journal, page 899).

OTHER 1959 RETEC PREPRINT BOOKS

★ **Vinyl Plastics**—Cleveland Section, 8 papers. $2.50 members; $3.75, non-members. (See program, SPE Journal, August, 1959 issue, p. 745).

★ **Plastics Finishing**—Buffalo Section, 4 papers, $2.00, members; $3.00 non-members. (See program, SPE Journal, September, 1959 issue, page 823).

★ **Encapsulation, Printed Circuits, and Fluidized Bed Processes**—Northern Indiana Section, 15 of 23 papers presented. $3.00, members; $4.50, non-members. (See program SPE Journal, April, 1959, p. 319).

★ **Plastics in the Automotive Industry**—Detroit Section, 4 papers, $2.00, members; $3.00 non-members. (See program SPE Journal, May, 1959, p. 443).

★ **A Designer's Look at Reinforced Plastics** from the Pleasure Boat, Aircraft and Missile Industries Viewpoint—North Texas Section, 6 papers. $2.00, members; $3.00, non-members. (See program SPE Journal, April, 1959, p. 324).

★ **Plastics in the Metals Industries**—Pittsburgh Section, 10 papers. $3.00, members; $4.50, non-members. (See program SPE Journal, April, 1959, p. 324).

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Vol. II—Processing of Thermoplastic Materials, 705 pages. $14.40, members; $18.00, non-members.

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Vol. V, 1959, New York City, 96 papers. $7.50, members; $12.50, non-members. Single preprints of individual papers, Vol. V, while they last, $0.25 each, members; $0.40 each, non-members.

Vol. IV, 1958, Detroit, 94 papers. $5.00, members; $7.50, non-members.

Vol. III, 1957, St. Louis, 60 papers. $5.00, members; $7.50, non-members.

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Baltimore-Washington RETEC all Set for December 1

Following are abstracts of four papers to be presented at the RETEC on Stability of Plastics. A total of nine papers will be presented, with the other five abstracts appearing in the October SPE Journal, page 897.

Localized Oxidation, in Polymers. Effect on Physical Properties

W. L. HAWKINS, W. MATREYEK AND F. H. WINSLOW BELL TELEPHONE LABORATORIES INC., MURRAY HILL, N. J.

The amount of oxygen reacting with polyethylene and other semicrystalline polymers in the solid state has been found to vary directly with amorphous content. The reaction was followed by determining changes in density, solution viscosity, dielectric and mechanical properties. Variations in mechanical properties with oxygen content were determined in a series of low, intermediate and high density polyethylenes. Loss and recovery of these properties are consistent with an oxidation process which weakens solid polymers by breaking molecular chains in the amorphous region between crystallites.

Thermal Decomposition of Unsaturated Materials

WILLIAM J. BAILEY, DEPARTMENT OF CHEMISTRY, UNIVERSITY OF MARYLAND

The study of model compounds in our laboratory has shown that any unsaturated substance containing a gamma hydrogen will undergo cleavage by a cyclic mechanism. Such compounds include esters, amides, vinyl ethers, allyl ethers, ketones, aldehydes, olefins, unsaturated alcohols, and unsaturated acids. Evidence, such as lack of rearrangement of products, stability of ring compounds that cannot form such an intermediate, direction of elimination, and tracer studies, indicates that these compounds decompose through a six-membered ring transition state that does not involve either free radicals or ionic intermediates.

Thus it appears that the presence of such a structure in a material constitutes a weak link that affects the thermal stability of the compound. This information can be used to design more thermally stable materials, such as polyester lubricants and polymers.

Chemical Structure and Stability Relationships in Polymers

B. G. ACHHAMMER, MAX TRYON, AND G. M. KLINE, NATIONAL BUREAU OF STANDARDS

Laboratory aging tests have been developed to evaluate polymer degradation, but in most cases these methods are limited to a relative comparison of materials under the specific conditions of a given test environment. Although these tests serve an immediate need in technical evaluation of polymers, it is recognized that more basic methods are required. A possible approach to these new methods is through an expanding knowledge of stability relationships between polymer structure and various environmental parameters.

Polymer Decomposition, Mechanisms, Energetics, and Thermodynamics

LEO A. WALL, NATIONAL BUREAU OF STANDARDS

The mechanism of polymer decompositions is now at a stage where a partial understanding exists for a rather large series of polymers. However, only a few have been investigated in sufficient detail to permit estimation of the activation energies and steric factors for the elementary processes. Since polymer decompositions occur in the condensed phase, assumptions valid in gas phase studies are not, in general, valid. Radical terminations are likely to be controlled by diffusion and hence will have relatively high activation energies. Dissociation energies for bonds in polymeric substances cannot be studied by the same technique applicable to studies of small molecules. The "equilibrium polymerization" and the "ceiling temperature" concept of thermodynamic approach, while of value for the production of polymers, are of little assistance to one interested in thermally stable materials.

Employment & Service Guide

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Manufacturers' Representatives

Handle choice line of automatic plastic injection molding machinery in following areas: North & South Carolina, Virginia, Georgia, Florida-Puerto Rico, Alabama, Mississippi, Louisiana, Missouri, Tennessee, Kentucky, Southern Illinois & Indiana, Chicago-Milwaukee, Iowa, Oklahoma, Kansas, California, Washington-Oregon. Interested only in hard-hitting individual or organization with qualifications to handle sales and service for this profitable line. This is a major line but compatible lines are accepted. In reply furnish full resume of qualifications and experience with present organization structure to Box 6259, SPE Journal, 65 Prospect St., Stamford, Conn.

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Professional Plastics Engineer

14 years experience—all phases—injection molding, development, production, engineering, planning, purchasing, packaging, estimating. Desire executive position. Reply Box 6659, SPE Journal, 65 Prospect St., Stamford Conn.

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Young man interested in permanent position. 5 year's experience as foreman; maintenance; overhauling Vickers double pumps; mold setup, etc. Reply Box 6559, SPE Journal, 65 Prospect St., Stamford, Conn.

Ten Years in Polyolefins

Plus extensive prior word in other thermoplastics. Extrusion, film, sheet, pipe, vacuum forming, some blow molding. Graduate engineer, under 40, with supervisory experience in production, development, technical service. Capable writer. Seeks responsible position with stable, progessive company where wealth of experience can justify four figure per month starting salary. Reply Box 6359, SPE Journal, 65 Prospect St., Stamford, Conn.

Plastics Plant Manager

Resourceful manufacturing and engineering executive, 10 years experience, all phases of injection molding. Proven record of accomplishment in engineering, manufacturing, planning, purchasing, cost reduction. Graduate engineer. Ability to get results. Desires challenging position. Reply Box 6459, SPE Journal, 65 Prospect St., Stamford, Connecticut.

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Barber Colman Co., Wheelco Div. 928, 929
Bee Chemical Co., Logo Div. 945
Celanese Corp. of America—Chemical Div. 924, 925
Celanese Corp. of America—Plastics Div. 947
Cadet Chemical Corp. 917
Columbian Carbon Co. 985
Detroit Mold Engineering Co. 986
Devoe & Raynolds Co., Inc., Jones-Dabney Co., Div. 934
Dow Chemical Co. 954
Durez Plastics Div., Hooker Chemical Corp. 1001
Eastman Chemical Products, Inc.—Plastics Div. ... 990, 991
Frank W. Egan & Co. 1007
Farrel-Birmingham Co., Inc. 926
Farrel-Birmingham Co., Inc., Watson-Stillman Press Div. 940
General Dyestuff Co. 933
General Motors Corp., Oldsmobile Div. 1006
Gering Products, Inc., Div. Studebaker-Packard Corp. 935
W. R. Grace & Co., Polymer Chemicals Div. 922, 923
Hartig Extruders, Div. of Midland-Ross Corp. 952
Hooker Chemical Corp.—Durez Plastics Div. 1001
Improved Machinery, Inc. 946
Injection Molders Supply Co. 988
Jones-Dabney Co., Div. of Devoe & Raynolds Co., Inc. 934
Lester-Phoenix, Inc. 997
Logo Div., Bee Chemical Co. 945
Metal & Thermit Corp. 948
Midland Ross Corp., Hartig Extruders Div. 952
Modern Plastics 944
Monsanto Chemical Co.—Organic—Plasticizers ... 938, 939
Monsanto Chemical Co.—Plastics Div. 953
National Aniline Div.—Allied Chemical Corp. 932
National Distillers & Chemical Corp., U. S. Industrial Chemicals Co., Div. 949, 950
Oldsmobile Div., General Motors Corp. 1006
Package Machinery Co.—Reed-Prentice Sales Div. ... 912
Phillips Chemical Co. 1013
Plastics & Coal Chemical Div., Allied Chemical Corp. 920, 921
Plastic Materials & Polymers, Inc. 998
Prodex Corp. 982
Reed-Prentice Sales Div., Package Machinery Co. 912
John Royle & Sons 942
Sandoz, Inc. 951
Spencer Chemical Co. 943
Sterling, Inc. 1002
F. J. Stokes Corp. 1005
Studebaker-Packard Corp., Gering Products, Inc. Div. 935
Thoreson-McCosh, Inc. 1000
Tokuda Seisakusho, Ltd. 997
Union Carbide Plastics Co., Div. of Union Carbide Corp. 930, 931
U. S. Industrial Chemicals Co., Div. of National Distillers & Chemical Corp. 949, 950
U. S. Stoneware 941
Van Dorn Iron Works Co. 1014
Watson-Stillman Press Div.—Farrel-Birmingham Co., Inc. 940
West Instrument Corp. 995
Wheelco Div., Barber Colman Co. 928, 929
Witco Chemical Co. 927

NEW DESIGNS IN MARLEX

New 22-ounce Armour Chiffon detergent containers made of MARLEX* show tremendous sales increase over metal cans!

The big news in household products packaging today is the switch from metal and glass to containers made of rigid polyethylene. In addition to being lighter in weight, these plastic bottles cannot rust to leave unsightly rings on shelves and porcelain surfaces. They do not dent . . . will not nick porcelain, won't chip dishes or glassware, if accidentally dropped. And—very important—they can be designed in a wide variety of attractive and functional shapes, with the color molded in.

Like other leading detergent manufacturers, Armour and Company recognizes the many advantages of bottles blow-molded from MARLEX 5000 Series Detergent Grade Resin. MARLEX offers superior stress cracking resistance, longer shelf life, and greater stiffness and strength per mil of wall thickness.

MARLEX 5000 Series Resin is so chemical-resistant and impermeable that it is being widely evaluated for use as a container material for such hard-to-hold household products as laundry detergents, disinfectants, bleaches and toiletries, as well as waxes, polishes and cleaning agents.

In fact, no other type of material serves so well and so economically in so many different applications. How can MARLEX serve you?

*MARLEX is a trademark for Phillips family of olefin polymers.

PHILLIPS CHEMICAL COMPANY, Bartlesville, Oklahoma, A subsidiary of Phillips Petroleum Company

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East Providence 14, R. I.	New York 5, N. Y.	Akron 8, Ohio	Elmhurst, Ill.	Pasadena 1, Calif.	Dallas 25, Texas	New York 5, N. Y.
GEneva 4-7600	Digby 4-3480	FRanklin 6-4126	TErrace 4-6600	MUrray 1-6997	EMerson 8-1358	Digby 4-3480

MARLEX®

Hubley Tic Toy Clock—many of the 40 parts are made on The Lampeter Manufacturing Company's Van Dorns.

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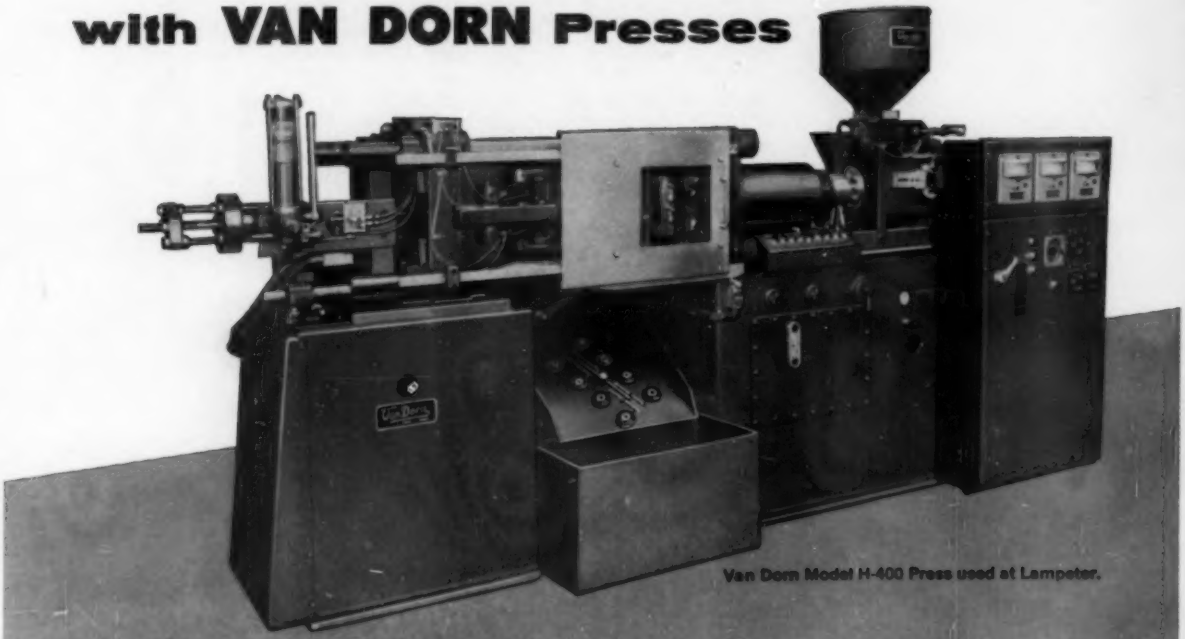
AUTOMATION

with VAN DORN Presses



Van Dorn Model H-400 Press used at Lampeter.

As a major supplier for The Hubley Manufacturing Company, a leading toy producer, The Lampeter Manufacturing Company is an extensive user of plastic machinery. Lampeter operates their fully automatic Van Dorn 4-6 oz. and Van Dorn 3 oz. presses *24 hours a day, six days per week.*

Besides a substantial reduction of cycle time, the company reports the Van Dorn presses are economical, versatile, and require minimum maintenance. The general manager says that if he buys more machines of the same size, Van Dorns would certainly be a top consideration.

You, too, can save time and money with Van Dorn high production injection presses. Write for detailed information.

Inspection of toy parts produced on the Van Dorn H-300.

Van Dorn

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